

CONDITIONS AND PRACTICES AT COAL MINES IN THE RUHR DISTRICT OF WESTERN GERMANY

BY J. B. BENSON, H. E. SANFORD, AND R. W. STAHL

* * * * * **Information Circular 7549**



UNITED STATES DEPARTMENT OF THE INTERIOR

Oscar L. Chapman, Secretary

BUREAU OF MINES

James Boyd, Director

Work on manuscript completed September 1949. The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is made: "Reprinted from Bureau of Mines Information Circular 7549."

February 1950

CONDITIONS AND PRACTICES AT COAL MINES IN THE RUHR DISTRICT OF WESTERN GERMANY

by

J. B. Benson,^{1/} H. E. Sanford,^{2/} and R. W. Stahl^{3/}

CONTENTS

	<u>Page</u>
Introduction.....	5
Summary.....	5
Acknowledgment.....	7
General.....	7
Coal measures.....	8
Classification of coal beds.....	9
Strip mining.....	10
Deep mining.....	10
Employment and production.....	10
Absenteeism and labor turnover.....	11
Surface structures.....	12
Preparation plants.....	12
Coal-storage bins.....	13
Coking plants.....	13
Electric power and compressed-air plants.....	13
Wash houses.....	14
Lamp houses.....	14
Shops and other buildings.....	16
Hoisting, cages, and shafts.....	16
Miscellaneous surface condition.....	18
Refuse disposal.....	18
Surface fire hazards.....	18
Underground mining methods and practices.....	18
Haulageways and airways.....	19
Longwall faces.....	19
Barrier pillars.....	20
Hand mining.....	20
Mechanical mining.....	21
Coal plows.....	21
Scraper loaders.....	22
Duckbill entry loader.....	23

^{1/} Mining engineer, Health and Safety Division, Birmingham, Ala.

^{2/} Mining engineer, Health and Safety Division, Johnstown, Pa.

^{3/} Mining engineer, Health and Safety Division, Wilkes-Barre, Pa.

CONTENTS (Cont'd.)

	<u>Page</u>
Underground mining methods and practices (Cont'd.)	
Roof support and backfilling.....	23
Kinds of roof.....	23
Roof support in entries.....	24
Face timbering.....	24
Backfilling.....	25
Explosives, detonators and blasting devices.....	26
Storage of explosives.....	26
Delivery of explosives.....	26
Blasting practices.....	26
Ventilation and mine gases.....	27
Mine fans.....	27
Coursing of air.....	27
Doors and stoppings.....	28
Liberation of methane.....	28
Gas-saving methods.....	28
Examinations for gas.....	29
Mine temperature.....	29
Coal dust.....	30
Explosibility of coal dust.....	30
Sources and accumulations of coal dust.....	30
Allaying coal dust.....	30
Rock dusting.....	31
Silicosis.....	31
Transportation.....	32
Haulageways.....	32
Tracks and switches.....	32
Clearance and shelter holes.....	33
Locomotives.....	33
Conveyors.....	34
Spiral chutes.....	34
Dispatching systems.....	34
Car-spotting hoists.....	34
Mine cars.....	34
Safety measures.....	35
Man-trips.....	35
Electrical installations.....	36
Substations.....	36
Power lines.....	36
Bonding.....	36
Pumps.....	36
Battery-charging stations.....	37
Telephones.....	37
Underground lighting.....	37
Guarding of machinery.....	37
Hand tools.....	38
Underground fire protection and control.....	38
Miscellaneous.....	38

CONTENTS (Cont'd.)

	<u>Page</u>
Underground mining methods and practices (Cont'd.)	
Miscellaneous (Cont'd.)	
Mine maps.....	38
Protective pillars.....	38
Escapeways.....	39
Miners' lamps.....	39
Check-in and check-out system.....	39
Protective clothing.....	39
Smoking.....	39
Housekeeping.....	39
General safety conditions.....	40
Mine inspectorate.....	40
Supervision.....	40
Safety organization and promotion.....	41
Accident statistics.....	41
First aid and mine rescue.....	45
Education and conditions of employment.....	45
Training of young miners.....	45
Status of a coal miner in Germany.....	46
Employment of aged or disabled miners.....	46
Insurance and hospitalization.....	46
Efficiency and cost of production.....	47
Efficiency of German mining system.....	47
Cost of production.....	47

ILLUSTRATIONS

<u>Fig.</u>	<u>Follows page</u>
1. Map of the Ruhr district.....	4
2. Organization chart, UK/US Coal Control Group.....	4
3. UK/US Coal Control Group headquarters in Essen...	4
4. Mine surface plant near business district of city in the Ruhr.....	4
5. Profile of coal beds in a typical mine in the Ruhr.....	8
6. Profile of coal beds in a typical mine in the Ruhr.....	8
7. Lignite bed showing thin layer of overburden.....	10
8. Overburden stripping machine.....	10
9. Stripping machine loading onto a cross-pit conveyor.....	10
10. Backfilling mined-out area of strip pit.....	10
11. Dredger-type loading machine, showing typical lignite face.....	10
12. Chain haulage system at a lignite mine.....	10
13. Typical surface plant in the Ruhr.....	12

ILLUSTRATIONS (Cont'd.)

<u>Fig.</u>		<u>Follows</u> <u>page</u>
14.	Typical dumping system, showing several dumps....	12
15.	Coal-storage bins.....	12
16.	Battery of byproduct coke ovens at a mine in the Ruhr.....	12
17.	Engine room at a mine-power plant in the Ruhr....	12
18.	Compressed-air lines.....	12
19.	German miners carrying hand lamps.....	14
20.	Group of mine officials wearing electric lamps...	14
21.	Hoisting engine of the type used at many Ruhr mines.....	16
22.	Headframe for heavy-duty hoisting in the Ruhr....	16
23.	Engine-room sheave for "Koepe" system of winding.	16
24.	Load equalizer for 4-rope hoisting.....	16
25.	System of mining, steep pitches.....	20
26.	System of mining, steep pitches.....	20
27.	Multi-step face in steeply (80°) pitching bed....	20
28.	Coal plow (Kohlenhobel) produces reasonably coarse coal.....	20
29.	Arrangement of hoists and pneumatic jacks for coal-plow face.....	22
30.	Typical scraper loader with extensible-type crossbars.....	22
31.	Duckbill entry loader in entry with steel arch supports.....	22
32.	Main haulageway, showing steel crossbars with wooden legs and lagging, and rock-dust barrier.	24
33.	Brick arches support roof and sides at wide places.....	24
34.	Commonly used adjustable steel props.....	24
35.	Extensible crossbars.....	24
36.	Roof support between crossbars.....	24
37.	Surface subsidence must be regulated in such areas.....	24
38.	Pneumatically packed backfill material.....	24
39.	Lay out of a typical underground explosives storage magazine.....	24
40.	Typical mine-fan installation.....	26
41.	Typical mine-ventilation map.....	26
42.	Crushing of overburden is a source of much fine coal dust.....	30
43.	Storage battery and combination battery-trolley locomotives.....	32
44.	Mother-belt conveyor suspended from roof.....	32
45.	Mine-accident trends, 1926-46.....	42
46.	Well-maintained mine-rescue station.....	44
47.	Training shop for apprentice miners.....	44



Figure 1. – Map of the Ruhr district.

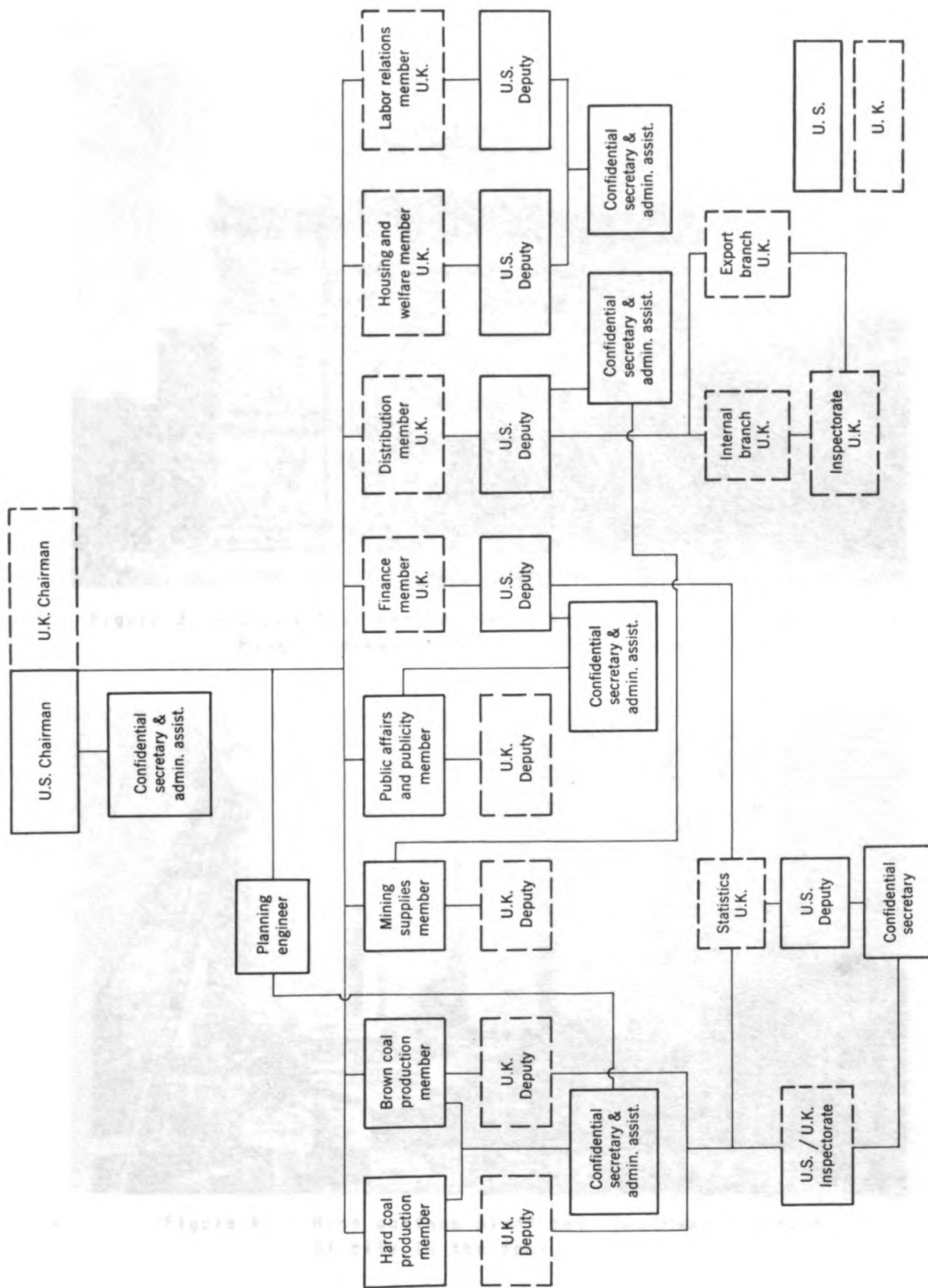


Figure 2. - Organization chart US/UK Coal Control Group.



Figure 3. - UK/US Coal Control Group headquarters in Essen (Villa Huegel, prewar home of the Krupp family).

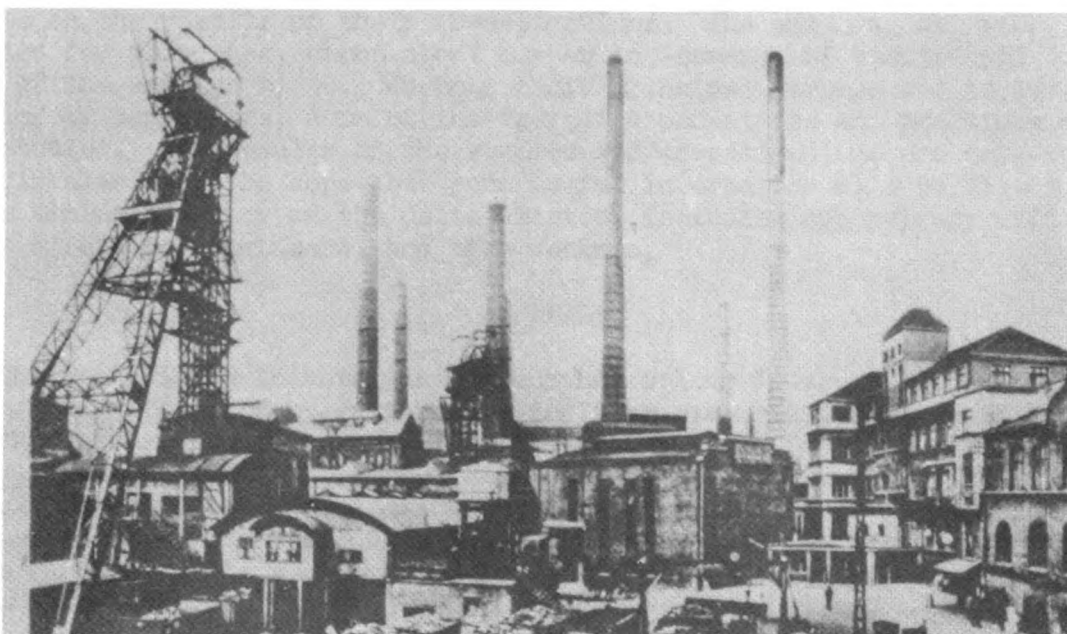


Figure 4. - Mine surface plant near business district of city in the Ruhr.

INTRODUCTION

Immediately following the capitulation of Germany in World War II, the German State was occupied by various allied forces, who supervised all industrial activities in the area. Coal production is vital to the industrial life of Germany, and most of the coal is mined in the American- and British-occupied zones of western Germany. The British-occupied zones include the Aachen and Ruhr districts, from which approximately 90 percent of the coal is obtained. Figure 1 is a map of the Ruhr district. Because of the magnitude of the task of insuring an adequate supply of coal and the necessity for united action, it was deemed best to reorganize the coal-producing facilities in the British zone under the joint supervision of American and British authorities. As a result, the UK/US Coal Control Group was established according to the organization plan indicated in figure 2. Headquarters for the group was established at Essen, in Villa Huegel, the prewar home of the Krupp family (fig. 3).

One of the many problems recognized immediately by the UK/US Coal Control Group was the necessity of preventing disasters and reducing accidents to workmen in mines under military-government control. Consequently, the United States Bureau of Mines was requested to furnish the services of qualified men to search for the hazards incident to coal mining and to prepare comprehensive reports on the results of their investigations. The authors, who were selected for this task, spent about a year in Germany and visited all except a few of the smaller mines. Whereas their principal purpose was to investigate safety conditions, some of the operating conditions and practices also were studied. The results of the studies and investigations are embodied in this circular with the hope that some useful information will be disseminated to the mining industry of the United States, including supervisory officials, safety directors, engineers, and mine workmen.

SUMMARY

The coal-mining industry in Germany has a long future life. Coal beds in the active field of operations are far from exhaustion, and it is known that they extend far beyond the limits of the present field in the Ruhr valley. The preparation plants are generally efficient and compare favorably with similar American installations. A large part of the coal is made into coke, and some of the byproducts are processed by the coal companies. Many of the surface plants were damaged severely during World War II; nevertheless, much of the equipment has been repaired and is in operation.

Virtually all coal in Germany is mined by the longwall system, longwalls ranging from 180 to 3,600 feet in length. Coal beds range in thickness from 12 inches to 16-1/2 feet, the average, including impurities, being 52 inches. Faults, anticlines, and synclines are numerous, and inclinations range from horizontal to vertical. Only a small amount of the total production of coal is mined mechanically, and not more than 6 percent is blasted.

Timbering practices are good, particularly along the haulageways. Steel props are used to support the roof along faces inclined less than 30 degrees, and wooden props are used on the steeper pitches. Backfilling is a common practice, because mining is conducted under areas where surface subsidence must be regulated carefully.

In several mines more than a million cubic feet of methane is liberated daily, but the ventilating systems are efficient. Nearly every longwall face and haulageway is ventilated by separate splits of intake air, and gas was discovered with a flame safety lamp at only a few places during the visits of the authors. Temperatures were very high in many of the mines visited.

Much fine coal dust is produced through crushing of coal by pressure of overlying strata, the use of percussion picks, and at the numerous transfer points along conveyor lines, but very little effort is made to allay the dust at its sources. Accumulations of coal dust existed along virtually every longwall face and in return airways. Generalized rock dusting is not done, but many rock-dust barriers are installed along the haulageways and in air courses. Silicosis among coal miners is common, because little effort is made to prevent the men from breathing siliceous dust produced during backfilling or dry drilling of rock.

Main haulage is accomplished principally with compressed-air, storage-battery, Diesel, and trolley-type locomotives, and gathering haulage is done by car-spotting hoists and conveyors of various types. Mine cars are generally of not more than 1-ton capacity and are hoisted in cages and dumped on the surface. Shafts are small in cross-sectional area, and the average depth is 2,300 feet; consequently, multiple-deck cages are in general use. The cage guides in many shafts were worn excessively. The normal hoisting speed for coal is about 3,600 feet per minute, and the speed for hoisting men is limited by law to 1,560 feet per minute.

Except for electrical equipment near the shaft bottoms and trolley locomotives in a few mines, very little electrical equipment is used underground. Generally, the wiring was well-installed, but the insulation was poor. All underground electrical equipment is approved by the German Mine Inspectorate. Guarding of mechanical equipment was inadequate. Little effort was made to guard equipment used at the working faces, and material for guarding equipment on the surface was virtually unavailable. The supply of tools of all kinds was inadequate.

The means for combating underground fires is excellent. Compressed-air lines extend from the surface to virtually every place underground, and arrangements are made to convert the air lines to water lines in an emergency.

Necessary precautions were not always taken when the workings were advancing toward abandoned places and the workings of adjacent mines. Eleven men were drowned in 1948 when the workings of one mine cut into the abandoned workings of another. The check-in and check-out systems do not afford positive identification of employees working underground. There were at least two routes to the surface from nearly every working place. Smoking in German coal mines is prohibited by law, and there was no evidence that the law had been violated. Hand-held electric lamps are used for portable illumination underground, but there was a serious shortage of such lamps at many mines. Nearly all underground workmen wear protective caps of thick leather, but virtually none wore protective shoes.

The number of supervisors was adequate, and they appeared to be well-qualified for their work; however, there was considerable evidence that they were not maintaining discipline among the workmen. One of the most frequent explanations for this was that the supervisors were afraid they would be accused of being former Nazis and would be dismissed by the company and prosecuted by the occupation authorities.

Safety organizations of employees and officials are not established, and joint safety meetings are not held. The mining regulations established by the Mine Inspectorate serve as safety standards, but many of the rules were not being carried out, and the accident rate among miners was high. Nearly all miners are trained in first-aid work, but the supply of first-aid equipment was inadequate. Many coal companies maintain well-equipped mine rescue stations with full-time attendants in charge; at each mine where such a station is maintained, several teams of men trained for mine rescue work are available. Virtually every coal company maintains a miner-training school for juveniles. Boys are accepted as students when they become 14 years of age, and after 2 years' training at various surface occupations they are permitted to go underground for 2 more years of training. Statistics indicate that miners who prepared themselves by completing such training courses were more efficient and less likely to be injured than men not so prepared.

ACKNOWLEDGMENT

The authors are grateful for the assistance and information furnished by Dr. Fritzsche, Dean of Mining at the University of Aachen; Dr. Steiner, Bergwerks Director of the Emscher-Lippe mine at Datteln; Dr. Kottenburg, Bergwerks Director of the Königen Elizabeth mine at Essen-Frillendorf; Bergassessor Fritz Lange, Hannover-Hannibal mines, Bochum-Hordel; and all the officials of the Oberbergamt, Dortmund. Without the assistance of these and other persons connected with the coal-mining industry in western Germany, this publication would not have been possible.

GENERAL

Approximately 165 coal mines were operated in the American- and British-occupied zones of western Germany during 1948. This includes 9 mines in the Aachen area, 6 in Bavaria, and 150 in the Ruhr and Niedersachsen districts, but does not include the mines in the lignite field near Cologne. The Bavarian mines were in the American-occupied zone and produced about 2 percent

of the coal mined in western Germany. Many of the mines, particularly those in the Ruhr, are in densely populated areas, and some of them are near the centers of large cities (fig. 4). The city of Essen, with a prewar population of about 670,000, is considered the coal capital. It is situated near the western boundary of the Ruhr field, and more than 4,500,000 people are living within 40 miles of this city.

The Ruhr coal field is about 75 miles long and 35 miles wide and is interlaced by a system of railroads, streetcar lines, highways, rivers, and canals. Many coal companies constructed docks on the rivers and canals, and a large part of the Ruhr coal was transported in barges to Belgium, France, Holland, and the North Sea. Several mines in the Ruhr have been in operation for more than 100 years, and the future life of many of them is estimated at 150 years. Many of the Ruhr coal beds fire spontaneously, and mine fires are not uncommon. A mine explosion in 1947 resulted in a large loss of life; however, such disasters have been rare in the history of the district, and comparatively few lives have been lost in mine fires.

The surface in the Ruhr coal field is fairly flat, and all the active mines are opened by shafts. A few mines at the south end of the field were opened years ago by slopes, but such mines were small and have been abandoned. Some of the shafts are more than 4,000 feet deep; however, the average depth is 2,300 feet and is increasing at the rate of about 20 feet a year as the coal in the upper beds is mined out. Generally, only two single-compartment shafts were sunk to open each mine. This was due to the depth of the coal below the surface and the frequent necessity of penetrating a thick deposit of quicksand. At several places the quicksand is 300 feet thick, and shafts through it were made by first freezing the sand and then excavating through the frozen material. The average prewar cost of shaft sinking was about \$1,000 a foot, according to Dr. Fritzsche, dean of mining at the University of Aachen.

There are about 75 coal beds in the Ruhr field, 50 of which are workable and have a total thickness of about 225 feet. The thickness of the beds ranges from 8 inches to 16-1/2 feet; the average thickness is 52 inches, including 4 inches of impurities. The lower limit of workable thickness at the time of preparation of this circular was about 12 inches. Overburden above the top coal bed ranges from nothing in the southern end of the field to 1,800 feet in the northern end; however, it is known that the coal measures extend far beyond the boundaries of the currently active field.

COAL MEASURES

Although the surface of the Ruhr coal field is relatively flat, the coal measures are badly faulted and folded, with the result that numerous anticlines and synclines are encountered in every mine, and the coal beds are reasonably flat only at the bottom and top of the folds. The strike is parallel with the long axis of the coal field, and its direction is northeast-southwest; the general dip is to the northwest. Besides folding, extensive cross faulting prevails and, in addition, a certain amount of strike faulting of an overthrust nature occurs, which results locally in combining or obliterating some of the coal beds. Figures 5 and 6 are profile drawings of coal beds in typical mines.

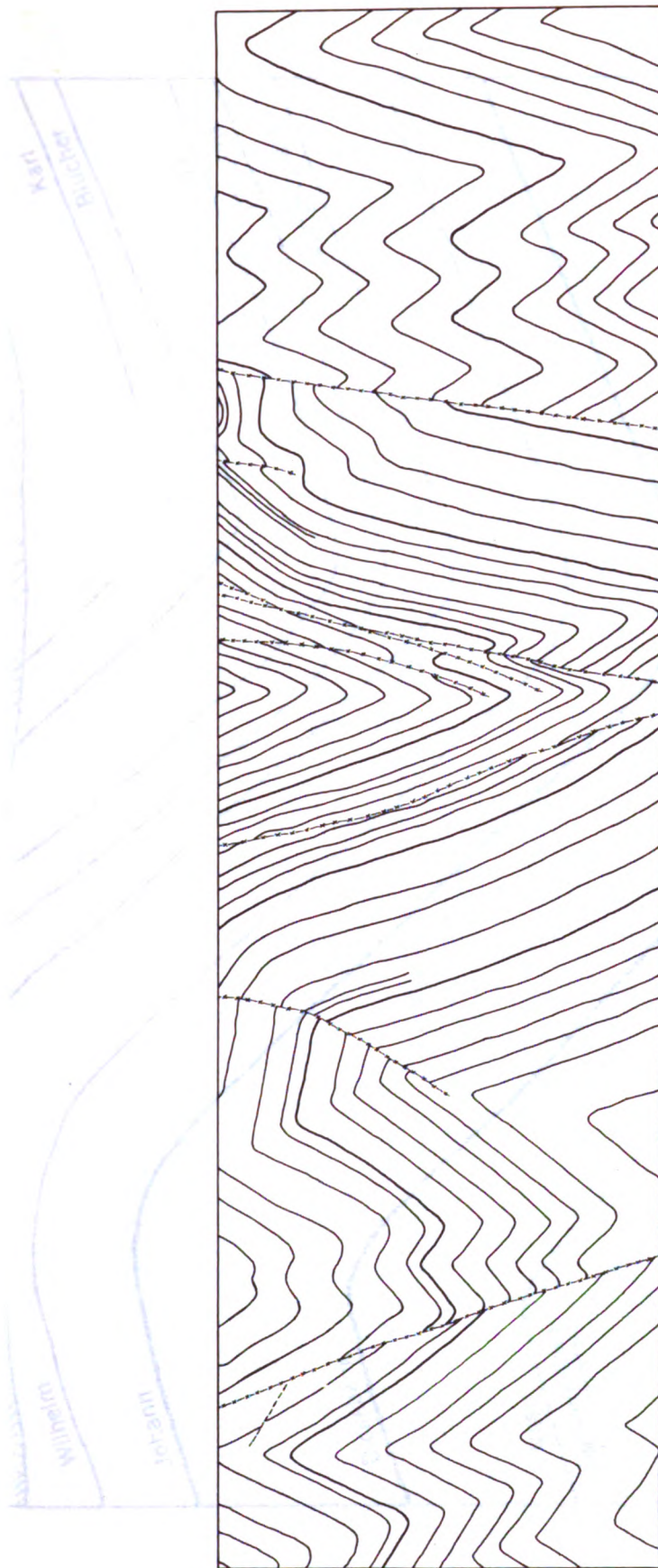


Figure 5. - Profile of coal beds in a typical mine in the Ruhr.

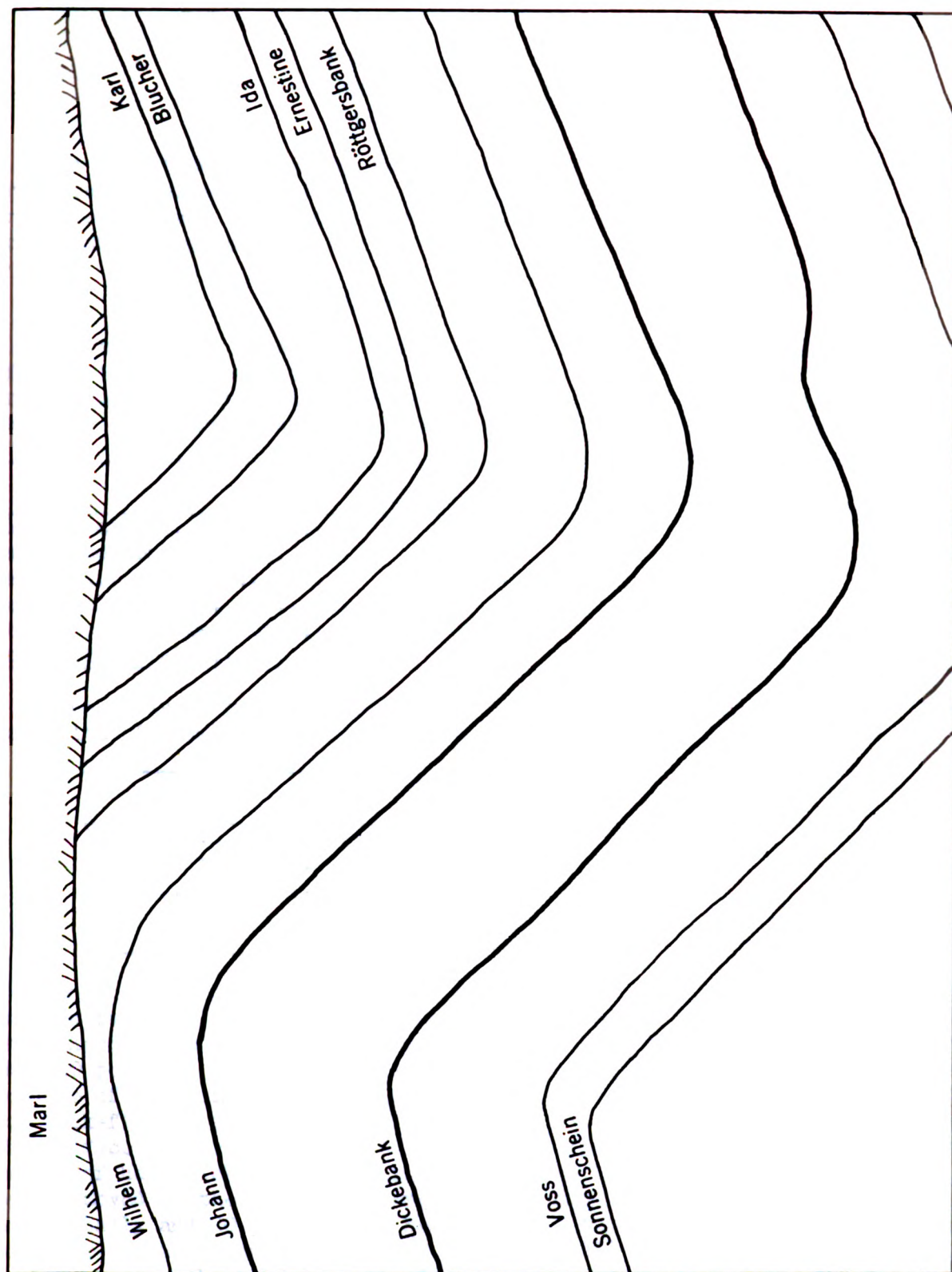


Figure 6. - Profile of coal beds in a typical Ruhr mine.

Inclinations of coal beds are classified in Germany as follows:

	Degrees
Flat.....	0 to 26
Semisteepest...	26 to 35
Steep.....	More than 35

It is estimated that 65 percent of the coal produced in the Ruhr comes from the so-called flat beds, 9 percent from semisteepest beds, and 26 percent from steep beds. About one-third of the coal reserves are in beds inclined at more than 35 degrees from horizontal.

Classification of Coal Beds

Virtually all classes of coal are found in the Ruhr, although the method of classifying them differs from that employed in the United States. There are six principal classifications, and several coal beds in each group. The names of these groups and approximate analyses of the raw coal follow:

	Percent			
	Volatile	Moisture	Ash	Fixed carbon
Flame coal.....	40-45	3-5	6-10	40-51
Gas-flame coal.....	35-40	3-5	6-10	47-54
Gas coal.....	30-35	3-5	6-10	52-61
Fett coal.....	19-30	1-5	6-14	57-72
Meager coal (steam coal)....	13-19	3-5	6-10	68-78
Anthracite coal.....	7-13	3-5	6-10	75-84

The analyses of a channel sample from a bed in the fett-coal group and a composite of samples from four coal beds in this group are as follows:

	Channel sample, percent	Composite sample, percent
Ash.....	13.0	9.0
Volatile matter.....	25.0	26.0
Carbon.....	60.0	64.0
Moisture.....	2.0	1.0
	100.0	100.0

Most of the coal beds are free of pronounced dirt bands, but some of them contain bands of impurities that comprise 30 percent of the coal-bed thickness. The inherent ash content of the coal beds mined at the present time is less than 10 percent; however, considerable foreign matter was loaded with the coal because of the numerous faults, folds, wants, overlaps, etc., and the necessity for back-filling and stowing. The ash content of the raw coal delivered to the surface ranges from 10 to 30 percent and averages 20 percent. Only a small amount of hand-picking or cleaning was done at the working faces. Impurities were removed on the surface, where 80 percent of the output was washed mechanically and 20 percent was hand-picked. Generally, large sizes of coal were not produced, and at least 60 percent of the mine-run passed through 1/2-inch screens. About 60 percent of the total production is from the fett-coal

group and is used in making coke. Very few mines were operated in only one coal bed, and as many as 15 beds are worked simultaneously in some mines.

STRIP MINING

Several large strip mines were operated in the lignite field a few miles from Cologne. Known locally as "brown coal," the deposits range up to 160 feet in thickness and are under a comparatively shallow, sandy-loam cover. At one mine the bed was 150 feet thick and the overburden was about 50 feet thick; at another, the lignite was about 60 feet thick and the overburden 40 feet. The lignite is of comparatively recent geological origin and is a soft, coarse mass containing many well-preserved branches, trunks, and stumps of trees. It is free of impurities and so soft that it can be mined with dredger-type machines (fig. 8) without preparatory blasting. The lignite contained about 60 percent moisture, 22 percent volatile matter, and the calorific value was reported to be about 4,000 B.t.u. The moisture content of raw lignite was reduced to about 18 percent for pressing into briquets, which have a calorific value of about 8,000 B.t.u. No binder was used in manufacturing the briquets.

Generally, throughout the field overburden was stripped with dredger-type machines and then conveyed by belts across the open pit and deposited in the mined-out area (figs. 7, 8, 9, and 10). Where the top soil was fertile, it was stored temporarily and then replaced on top of the leveled waste in the back-filled area; otherwise, the backfill was merely leveled, and trees were planted thereon.

One mine produced about 14,000 tons of lignite a day with about 200 men, and another produced about 30,000 tons of lignite daily with 350 men. At both mines the lignite was loaded mechanically on two shifts with dredger-type machines, but the crews who stripped the overburden worked only one shift a day. The 160-foot bed was mined in two benches, whereas lignite was loaded from one level for the 60-foot bed. The raw lignite at some mines was transported to the preparation plant in steel cars of 10-ton capacity hauled by electric or Diesel locomotives, whereas at other mines it was transported in ordinary 1-ton mine cars attached to an endless chain (fig. 12).

Most of the pits were reasonably dry, and the slopes of the lignite face and overburden highwall were such as to prevent dangerous slides. The lignite fires easily, and it was learned that at least a few fires are certain at every mine during the period between the wet and dry seasons. Consequently, each mine had an elaborate system of water lines and facilities for fire fighting.

DEEP MINING

Employment and Production

Approximately 324,000 men were working in and about the deep coal mines in the Ruhr district, of which 251,400 men were employed underground; 124,400 of the underground employees were face workers. In addition to these, another



Figure 7. - Lignite bed showing thin layer of overburden.

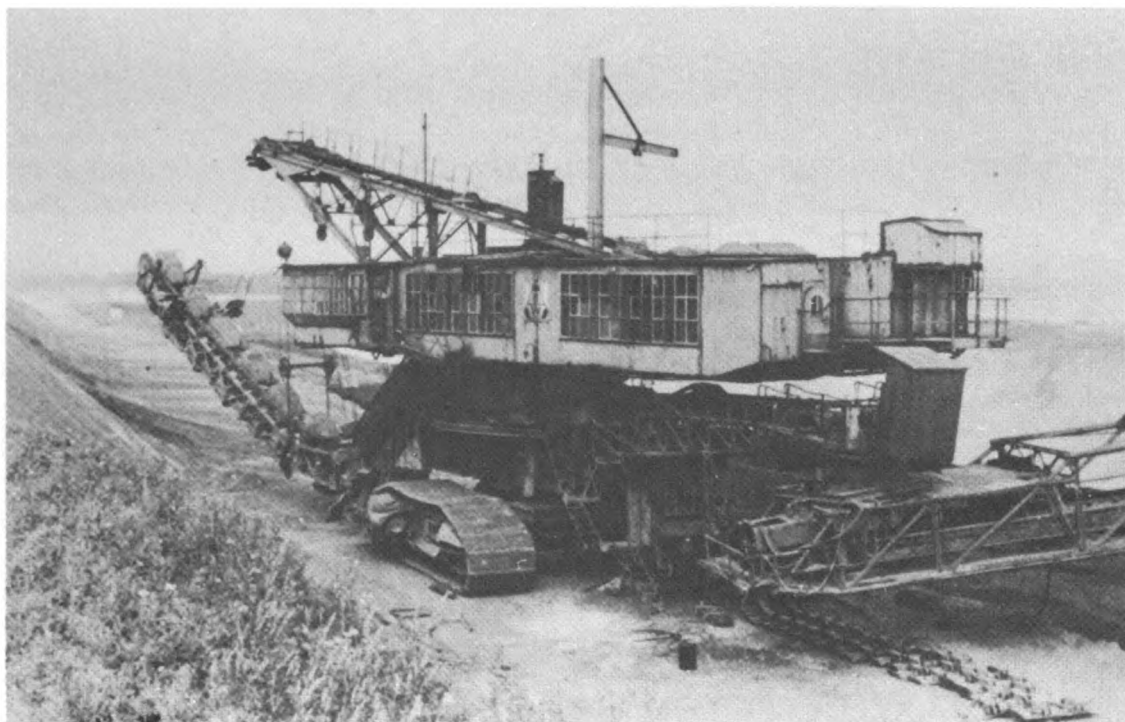


Figure 8. - Overburden stripping machine.

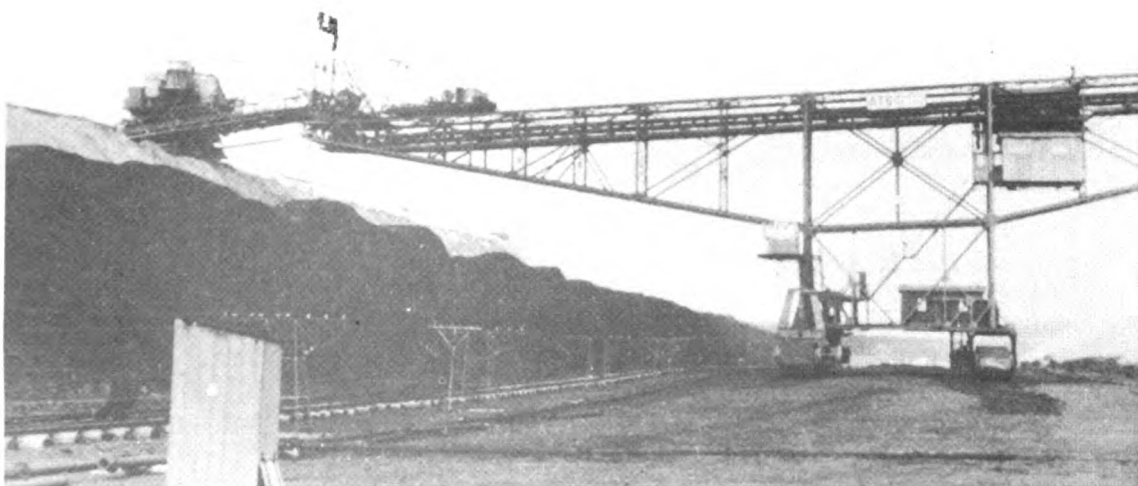


Figure 9. - Stripping machine loading onto a cross-pit conveyor.



Figure 10. - Backfilling mined-out area of strip pit.

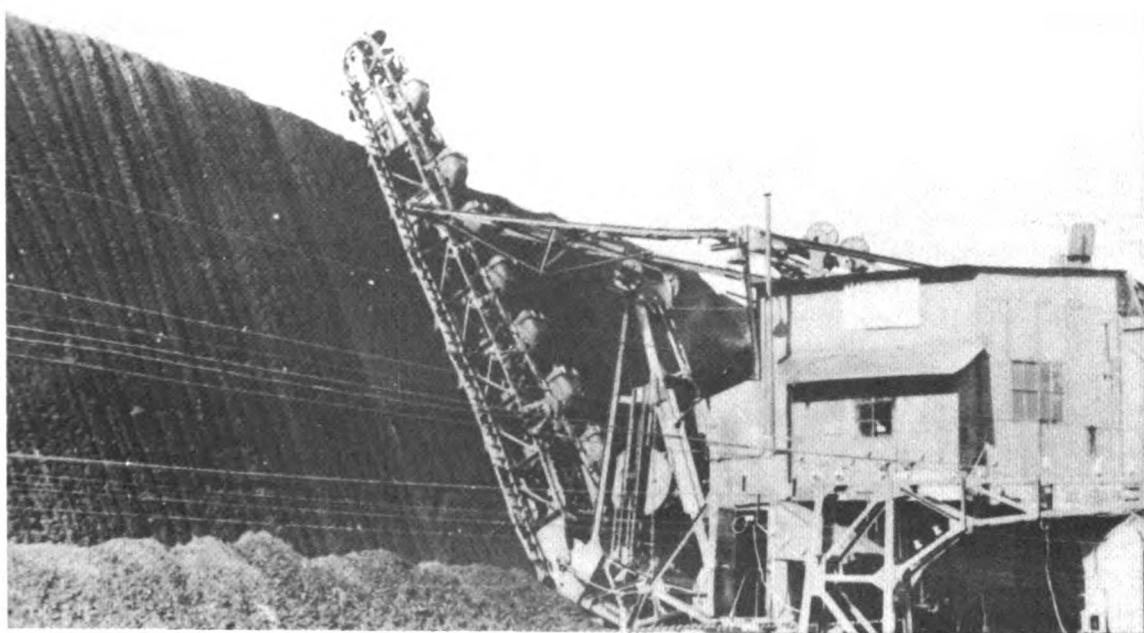


Figure 11. - Dredger-type loading machine, showing typical lignite face.

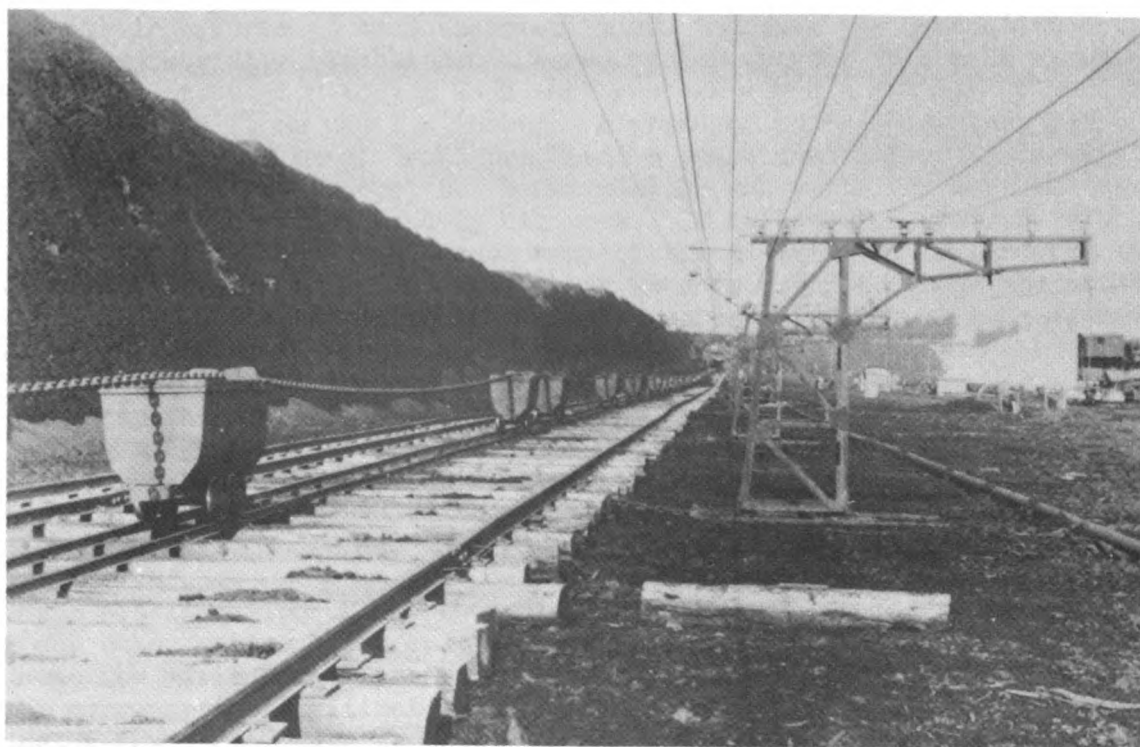


Figure 12. - Chain-haulage system at a lignite mine.

49,500 were doing closely related work, such as making coke, briquets, etc. Most of the mines produced coal on two shifts, and the average daily production from the field in January 1949 was about 330,000 tons. The average pre-war production was more than 400,000 tons, whereas the peak production obtained during the war was 467,953 tons in February 1943. Individual mines produced 500 to 6,000 tons a day, with an average of about 2,400 tons.

Absenteeism and Labor Turnover

Absenteeism was a major problem during the period from the end of World War II until the stabilization of currency in June 1948. Although several factors contributed to the high rate of absenteeism, probably the most important ones were the scarcity of food, the low purchase power of the Reichsmark, and the "black markets."

Despite the fact that anyone connected with the coal-mining industry was allowed extra ration points, the points were of little value because the legitimate markets were virtually devoid of merchandise. A miner could earn about 275 Reichsmarks (\$91.67) for a full month's work. A pound of butter cost 100 marks (\$33.33), coffee 350 marks (\$116.67) a pound, cigarettes 100 marks (\$33.33) a package, and other items at comparably inflated prices on the black market. The authors were told many times that, because of the scarcity of food from legitimate sources, few Germans could exist without some recourse to black markets. Thus, virtually every citizen was engaged to some extent in the black-market system of bartering and those who had nothing to barter had difficulty in existing.

In their efforts to curb absenteeism and increase the production of coal, the authorities established a bonus system whereby if a mine reached a prescribed production target each employee was given a package of hard-to-get items. Such items usually included a pound of coffee, two packages of cigarettes, two bottles of "schnapps," and a small quantity of oleomargarine. Thus, at black-market prices, the bonus package was worth far more to the miner than the money he earned by his work. It is doubtful whether this system reduced absenteeism, because many of the miners sold or bartered the bonus items and then lost time from their work in order to scour the countryside for food. Doctors' slips excusing the workers because of illness could be obtained without difficulty.

Another factor that contributed to the high rate of absenteeism during the spring and summer was the fact that nearly every person who could find seeds and a garden spot devoted a substantial part of his time to gardening. He could produce more of value to him by gardening than he could by working in a coal mine.

The stabilization of currency did more, perhaps, to reduce absenteeism than any other action taken by the authorities. The season of 1948 was a good one for agricultural products, and almost immediately after stabilization of the currency the legitimate markets began to fill with most of the necessities; a few items, such as potatoes and fresh vegetables, were removed from the list of rationed articles, and absenteeism dropped from an average of 22 to about 10 percent, which was approximately the prewar rate.

It was reported that the prewar turnover among miners was less than 1 percent a month; however, the postwar turnover at some mines was said to be 20 percent a month. Among the reasons given for this increase were the large number of displaced persons, the large number of inexperienced persons working as miners, and the housing shortage. Many of the displaced persons came originally from Silesia (now in the Russian zone), and many were from Poland and Czechoslovakia. These men had no family ties and roamed about from mine to mine merely for the change in scenery, so it was said. Many inexperienced persons entered the mines in order to enjoy the special privileges that were accorded to coal miners and, particularly, to be eligible for extra ration coupons. Company officials said these men, upon finding the work not to their liking, changed jobs frequently in the hope of finding more suitable work without losing their special privileges.

A large number of miners in prewar Germany owned their own homes, whereas others lived in company-owned dwellings so long that they possessed a feeling closely akin to ownership. It was estimated that more than half of these residences were destroyed or damaged severely by aerial attacks during the war; consequently, only a few of the miners were living in suitable quarters, and the others moved frequently in order to improve their housing facilities. It was not unusual for several families to share one residence, and, in particularly devastated areas, the authorities required each two rooms to be shared by at least three persons; thus, in many instances as many as four families shared one kitchen.

SURFACE STRUCTURES

Preparation Plants

The entire surface plant at virtually every mine is enclosed by at least an 8-foot fence of brick or concrete, and watchmen at each gate challenged every unknown person who attempted to enter. Virtually all coal from the Ruhr mines required extensive preparation in order to obtain acceptable products. The larger sizes, which composed about 20 percent of the output, were hand-picked, and the remaining 80 percent was cleaned by other methods.^{4/} Therefore, large surface plants are common at the mines (fig. 13). Usually they are erected near the shaft and are constructed of steel and brick or concrete. Mine surface plants were important targets during the war, and many of them were damaged severely by the aerial attacks of Allied air forces. Some of these plants were so completely demolished that they probably will not be rebuilt.

Virtually every preparation plant was equipped with facilities for crushing the larger sizes of coal. Various types of crushers were used, but the most common were the roll and jaw types. The coal was sized by rotating, inclined or horizontal shaking, and vibrating screens. Each plant was equipped with conveyors for mixing and blending the various sizes and types of coal. Some plants could prepare and load as many as six different sizes of coal simultaneously.

^{4/} Graham, H. G., and Schmidt, L. D., Methods of Producing Ultra-clean Coal for Electrode Carbon in Germany: Bureau of Mines Inf. Circ. 7481, 1948, 13 pp.



Figure 13. - Typical surface plant in the Ruhr.

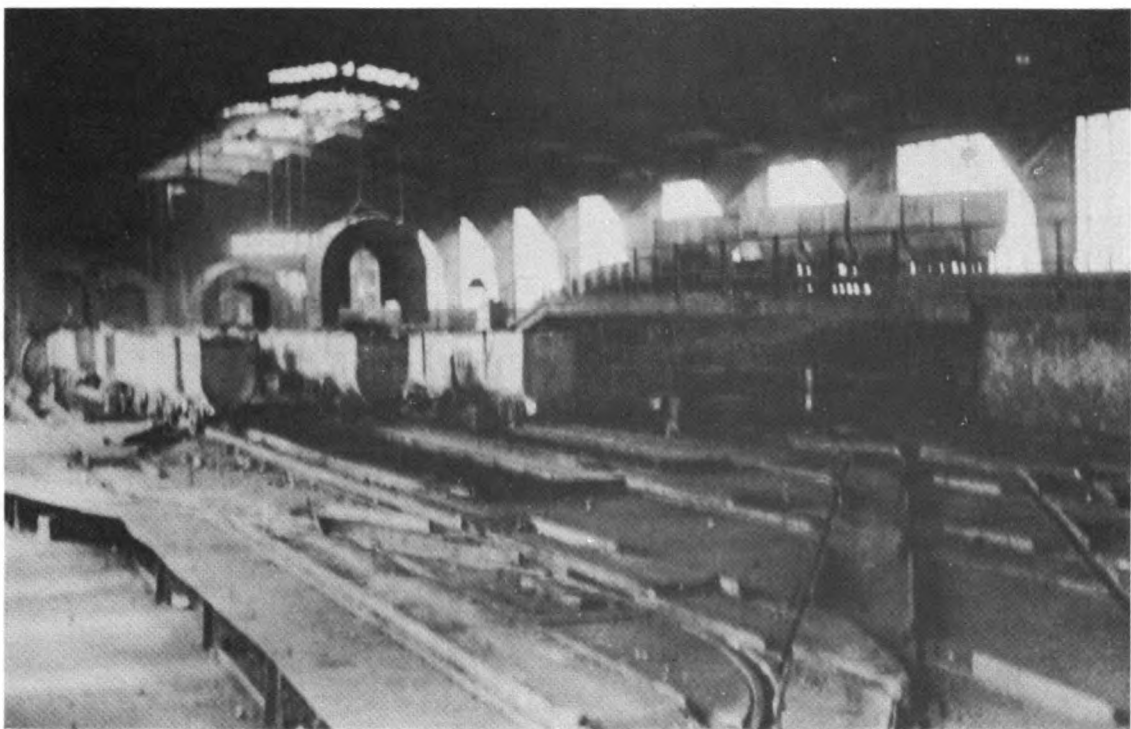


Figure 14. - Typical dumping system, showing several dumps.

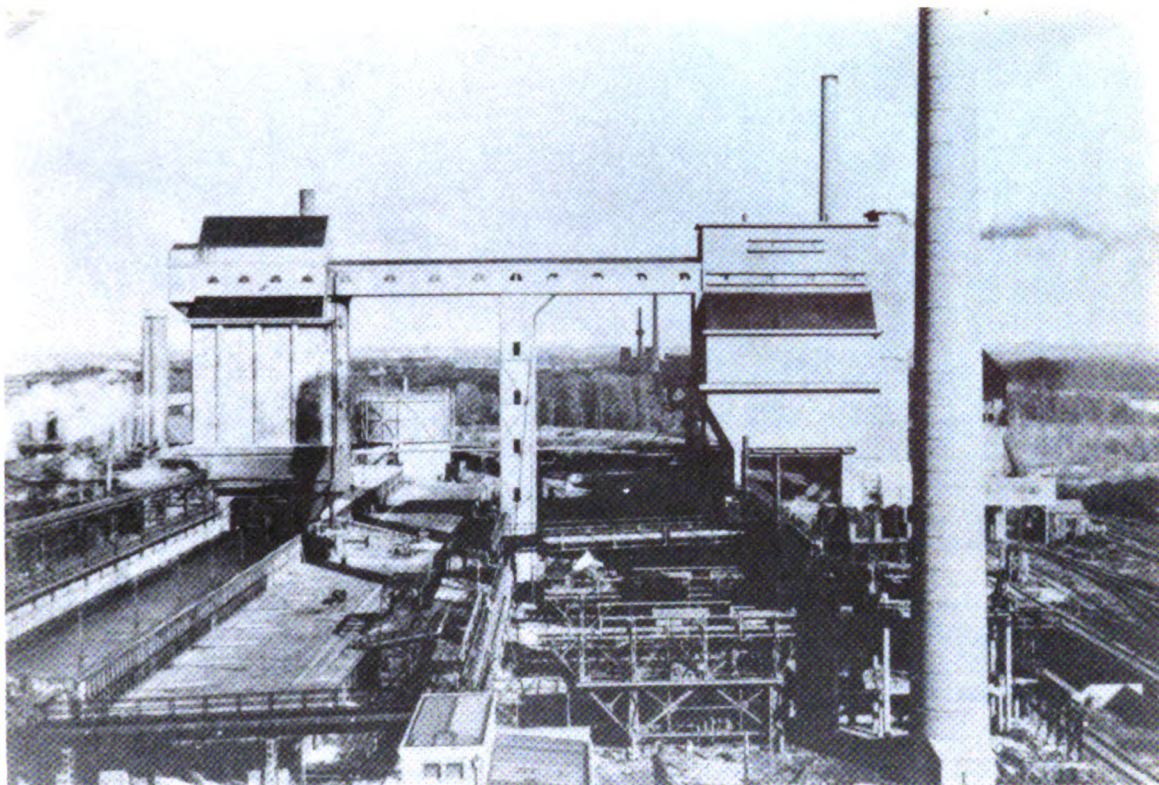


Figure 15. - Coal-storage bins.

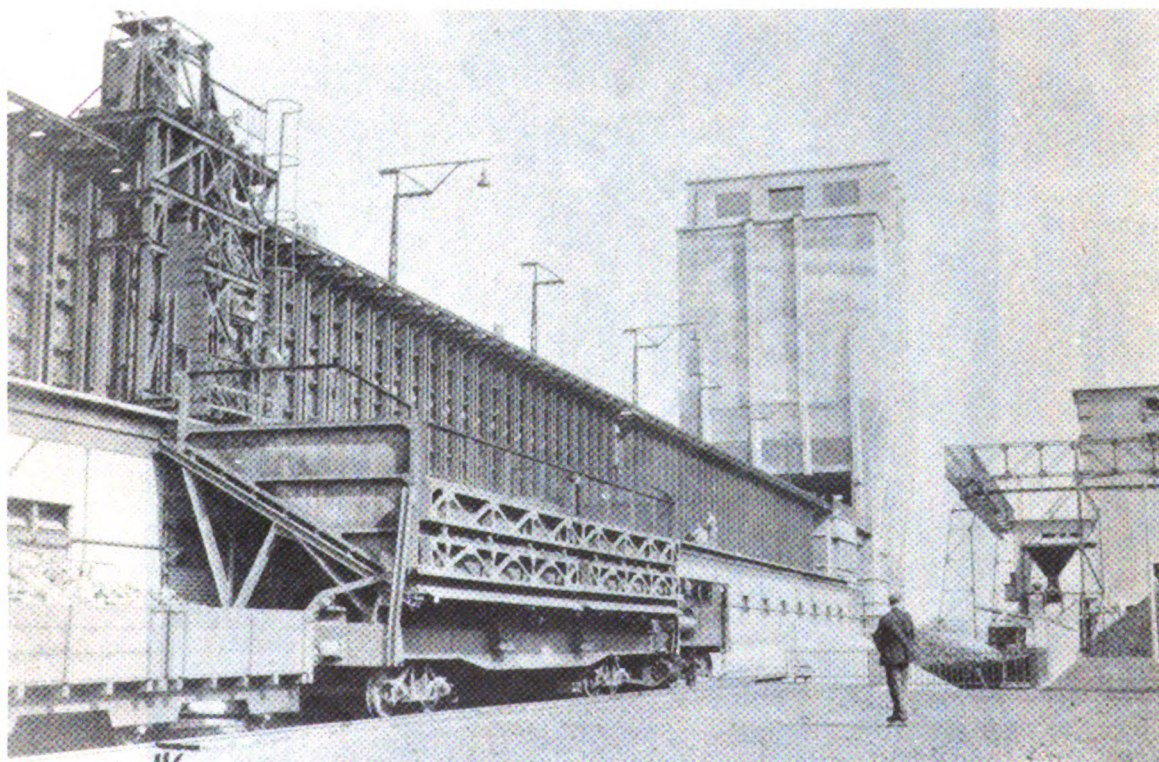


Figure 16. - Battery of byproduct coke ovens at a mine in the Ruhr.



Figure 17. - Engine room at a mine-power plant in the Ruhr.



Figure 18. - Compressed-air line.

Most of the Ruhr coal requires careful preparation. A typical plant contained twin washeries, each with a capacity of 400 tons per hour. The raw coal was sized on 7 revolving screens and 1 shaking screen. The larger sizes were passed over 5 picking belts for hand-cleaning, and the smaller sizes were conveyed to the washeries. Each washery contained two jigs for the plus 0.4-inch size and two jigs for the minus 0.4-inch size and one rewashing jig. First, the minus 0.4-inch size was dewatered by four vibrating screens, after which the coal was conveyed to the dewatering towers, which had a total capacity of 4,500 tons.

Most of the electric motors, switches, and starting boxes in preparation plants were dust-tight; the electric wiring was installed safely; coal dust and refuse were not permitted to accumulate; and in winter heat was furnished by steam or hot water. Thus, the danger of fires or coal-dust explosions was minimized. Because of the small capacity of an average mine car, several rotary-type dumps usually are installed near the cage landings in each preparation plant (fig. 14). These dumps were enclosed at the top and sides; consequently, very little dust was thrown into the atmosphere and none of it entered the mines. Virtually all the preparation-plant electrical equipment was operated from central control rooms.

Coal-Storage Bins

Coal-storage bins were used at nearly every mine (fig. 15). Their capacities ranged from a few to several hundred tons, and they were constructed of steel or concrete. Coal was not stored in these bins for long periods, and there was no apparent danger of spontaneous combustion.

Coking Plants

Many of the coal companies in the Ruhr district operated byproduct coke ovens (fig. 16) at the mine whereas others operate central cokeries served by several mines. Although virtually all these cokeries were damaged seriously during the war, many have been repaired and are producing as much as 2,000 tons of coke daily. One central cokery consisted of 3 batteries of byproduct ovens with 45 ovens in each battery. The daily production from this plant was 700 tons of coke, 25 tons of ammonium sulfate, 50 tons of coal tar, 4,692 gallons of crude benzol, and 12,000,000 cubic feet of coke-oven gas. About half of the gas was used to heat the ovens. Another cokery produced a daily average of 5 tons of ammonium sulfate, 4 tons of crude benzol, 10 tons of coal tar, and about 1-1/2 tons of sulfur.

Electric Power and Compressed-Air Plants

Most of the coal companies in the Ruhr have facilities for generating electric power (fig. 17). Most of this power is used locally, but some of it is sold to other industries and to other coal companies. The facilities at the mines were generally adequate to meet requirements; consequently, very little electric power was purchased from commercial power companies by the mining industry.

The steam plants are constructed of steel and brick or concrete and are usually erected in the mine yards. The design of the power plants as well as of all other surface structures was influenced by architects who worked with engineers charged with responsibility for the erection of surface plants. As a result of this influence, all surface structures of a given plant are symmetrical. Many of the power plants are modern and efficient in every respect, but some are not.

Recent boiler installations were of the vertical-tube type designed to produce superheated steam at pressures up to 250 pounds per square inch. Some of the boilers were fired by hand, but most of them were fired by automatic stokers using crushed coal or by burners using pulverized low-grade coal. Invariably the smoke stacks were so erected as to prevent fly ash from becoming a nuisance to the community.

A large volume of compressed air is used in the operation of every coal mine in the Ruhr, and in some mines all of the mechanical equipment is operated by compressed air. The compressors usually are operated in conjunction with the steam power plants but are installed in separate rooms of the same building. Nearly every mine was equipped with both high- and low-pressure compressors. The high-pressure compressors developed pressures up to 2,400 pounds per square inch and supplied the underground locomotives; the low-pressure compressors delivered air at about 90 pounds per square inch for the operation of other mechanical equipment. Compressor capacities differed according to the requirements of individual mines. Some mines had compressor plants capable of delivering 90,000 cubic feet of air per minute at a pressure of 90 pounds per square inch and 2,000 cubic feet per minute at 2,400 pounds per square inch.

All steam and compressor equipment was protected by adequate safety devices with escape-valve discharges above the roof of the building, and every room containing such equipment was provided with at least two exits. Written records indicated that all boilers and compressors were inspected regularly by authorized persons.

Compressed air was transmitted underground through pipe lines installed in shafts and along main roadways. These pipe lines were as much as 24 inches in diameter for the low-pressure supply and 8 inches in diameter for the high-pressure supply. Receivers equipped with drains were installed at shaft landings and at strategic places along the main roadways. Section and distribution compressed-air transmission lines ranged from 1 to 8 inches in diameter, depending on air requirements. The larger-diameter pipes were fitted with flange couplings, whereas the smaller ones were fitted with ball-and-socket or "kwik"-type couplings using rubber gaskets. Threaded couplings were seldom used and then only at the locomotive-charging stations. The underground compressed-air lines were suspended from the roof or ribs (fig. 18).

Wash Houses

A wash house for employees is provided at each mine in the Ruhr district. Generally it is a part of the main administration building and connected with



Figure 19. - German miners carrying hand lamps.

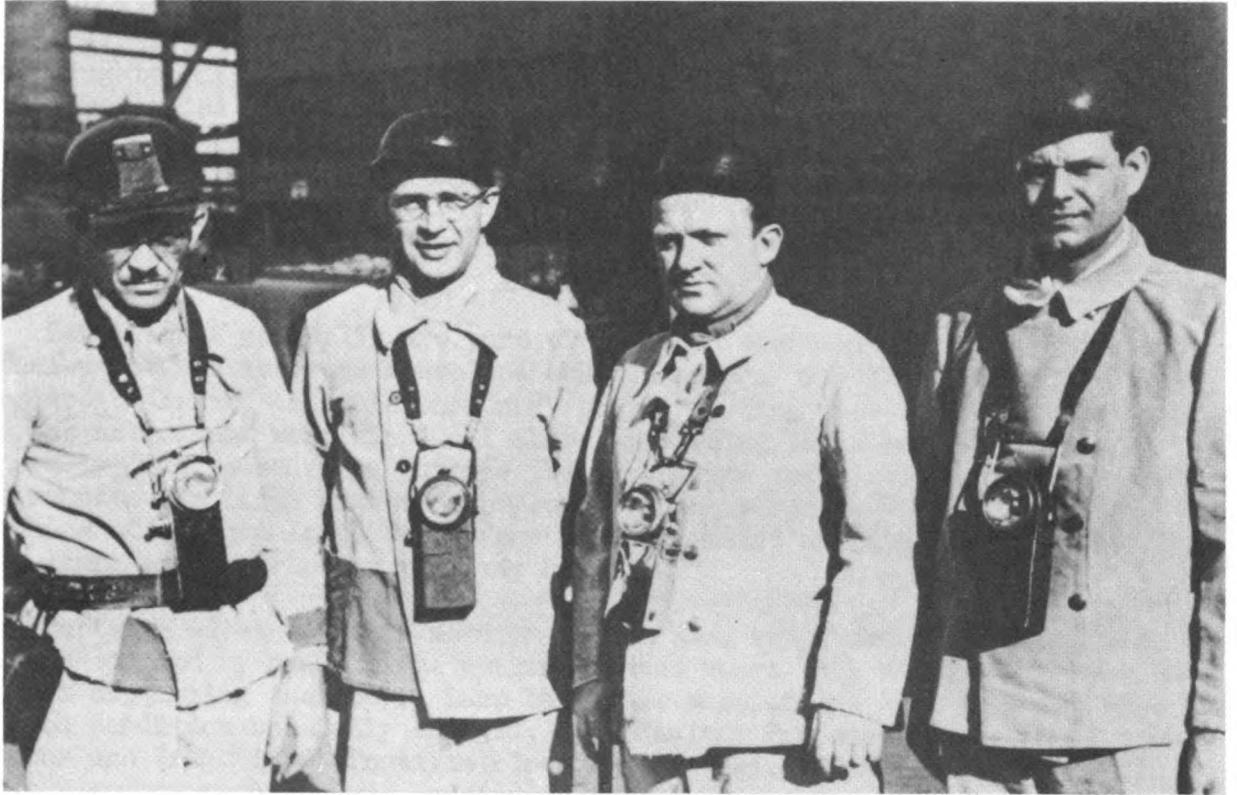


Figure 20. - Group of mine officials wearing electric lamps.

the shaft landings by an enclosure, so that men can travel between the wash house and the shaft without exposure to the elements. The mining law requires special rooms and shower baths for youths under 18 years of age; also, the hot-water boilers for the shower baths must be placed in separate rooms, and the water provided for bathing must be fit for human consumption. The wash houses are constructed of brick, concrete, or tile and were generally of ample capacity; some accommodated as many as 5,000 underground workers. A few, however, were destroyed by bombs during the war, and the temporary structures generally were inadequate in capacity. The wash houses were kept clean, well ventilated, and well heated, and many of them were equipped with facilities for laundering the employees' work clothes. The floors were treated regularly with a solution to reduce the spread of foot infection.

An innovation at some mines is the "black and white rooms." Employees preparing to enter the mine disrobe and place their street clothing in lockers in the so-called "white room," after which they enter the "black room" and don their mine clothing. The procedure was reversed upon leaving the mine, except that the men pass through the shower room after leaving the "black room."

Lamp Houses

Lamp houses generally are part of the main administration buildings and situated between the wash house and shaft landing. The lamp houses are constructed of brick, concrete, masonry, or tile. They were attended constantly, and the attendants maintained all lamps, including the flame safety lamps. Generally, two passageways outside the lamp house are provided in order to accommodate the large number of employees. One passageway serves for the issuance of charged lamps to the men going on shift and the other is used when lamps are returned to the lamp house.

Portable electric lamps used by the workmen weigh about 15 pounds each and are carried by hand to the working places where they usually are hung on timbers supporting the roof. Lamp batteries were of the acid type and when in good condition and fully charged, satisfactory for about 12 hours of continuous use (fig. 19). Portable electric lamps used by the officials weigh about 2 pounds each and are carried on the chest, supported by a leather strap around the neck (fig. 20). Some officials carry combination portable electric and flame safety lamps. The flame safety lamp is built on the back of the electric lamp and is rectangular in shape. The bonnet over the gauzes consists of two pieces of solid metal hinged on the sides and, when closed, shuts off the air circulation sufficiently to extinguish the flame. Instead of the conventional flint igniter, the flame safety lamp part is equipped with a small electric filament mounted directly above the wick. A small push-button switch controls the flow of current from the battery to the filament when lighting the lamp. The flame safety lamps in general use were similar in design and construction to those used in the United States, except that most of the lamps were not equipped with bonnets to protect the gauzes. Only those lamps used in high-velocity air currents were equipped with bonnets.

All lamps used underground for portable illumination or for gas-testing purposes were approved by the Mine Inspectorate.

Although the German mining industry has not developed portable methane indicators to the extent that has been done in the United States, they have developed a "salt pearl" for use with flame safety lamps by means of which as little as 0.1 percent methane is discernible on a "capping" flame. A salt pearl is about the size of the head of an ordinary household match and is made from Cerebos salt, a free-running salt obtained from England. The pearls are mounted on a stem or pin of magnesium oxide for insertion in the top of the safety-lamp wick. Salt pearls can be used only in lamps fitted with round wicks.

Shops and Other Buildings

Mine shops in the Ruhr district are larger and employ many more workmen than do similar shops at coal mines in the United States. They were usually well lighted, well heated, and well equipped. Virtually all old equipment is repaired in the shops, and much new equipment is built. As a rule, the equipment was well guarded, except where the necessary devices were unavailable; however, owing to the shortage of new equipment and the worn condition of the old, the floor in many of the shops was cluttered with defective machinery.

Kitchens and dining rooms were maintained at all mines after the war. Because of the food shortage and the necessity for reducing undernourishment among miners, each employee was allowed about a quart of stew and two sandwiches each day that he worked at the mine. Generally, the kitchens and dining rooms were attended by girls or women and were kept clean and sanitary. Many of the miners and officials shared the food issued to them at the mine with their families, instead of eating all of it themselves; thus, the food obtained at the mines did little to reduce malnutrition among the workmen. During the latter part of 1948, more food became available to miners, and most of them preferred to purchase food and have it prepared in their homes rather than pay for it at the mines.

On the whole, when one considers the damage done to surface plants by bombing during the war, the housekeeping practices were admirable. Attempts were made to store materials in an orderly manner, and the paths, roads, and walkways were reasonably free of stumbling hazards.

HOISTING, CAGES, AND SHAFTS

Virtually all hoisting engines in western Germany are operated by steam, although a few are operated electrically, and nearly all main hoisting shafts are equipped with four cages operated by two 1,500-horsepower hoisting engines. Where two hoists are used, the engines are in separate rooms, so that the signals and noise of one hoist does not interfere with the operator of the other. Engine houses are generally constructed of either brick or concrete, with tile or cement floors, and are fireproof throughout. The hoisting equipment includes automatic stop controls and devices to prevent overspeeding or overwinding; such devices were tested several times each shift. Both hand and automatic brakes are standard equipment for each hoist, and each brake

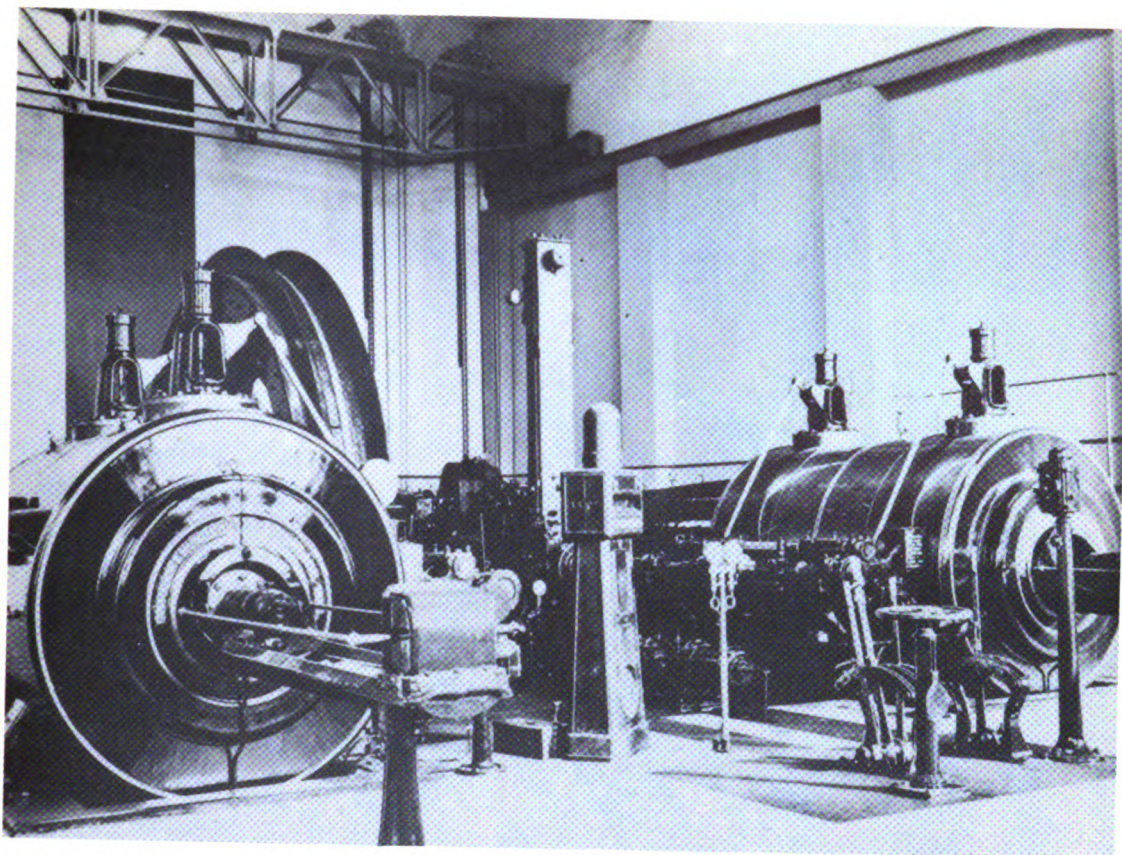


Figure 21. - Hoisting engine of the type used at many Ruhr mines.

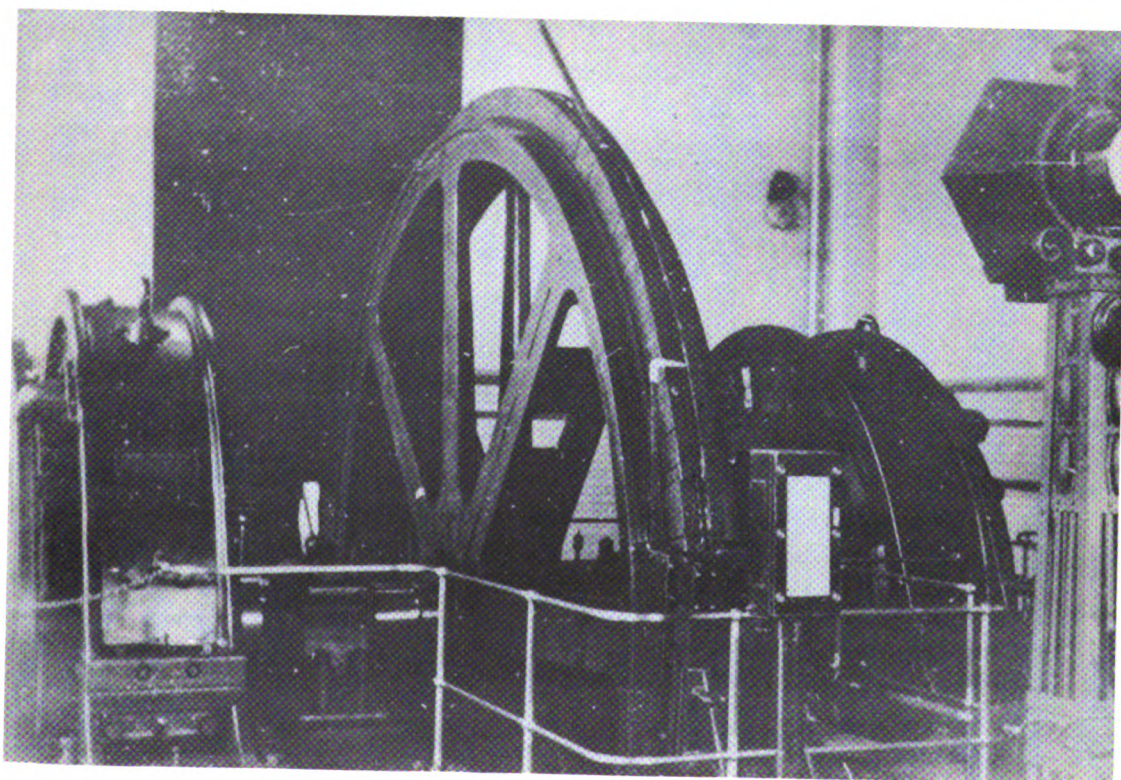


Figure 22. - Engine-room sheave for "Koepe" system of winding.

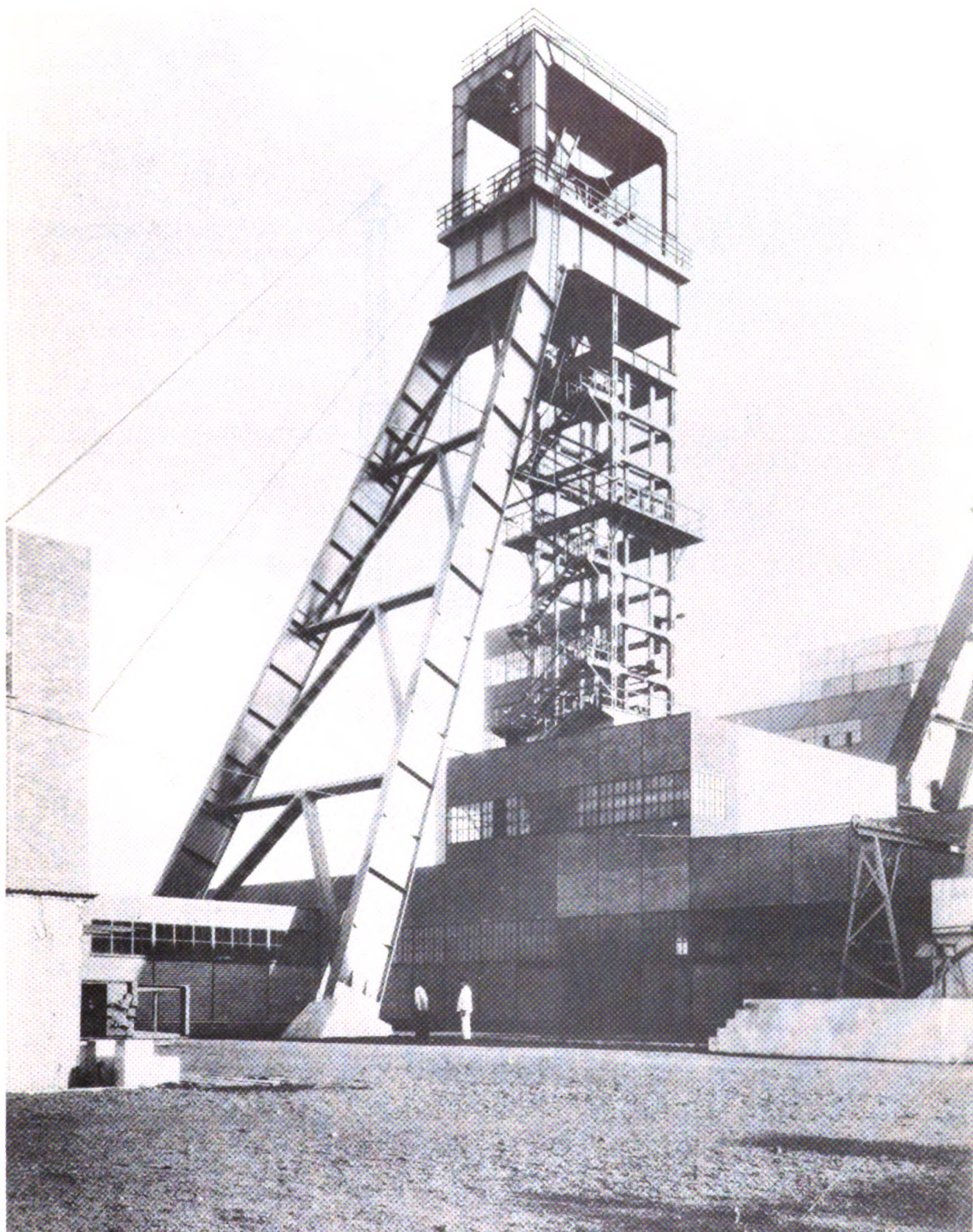


Figure 23. - Headframe for heavy-duty hoisting in the Ruhr.

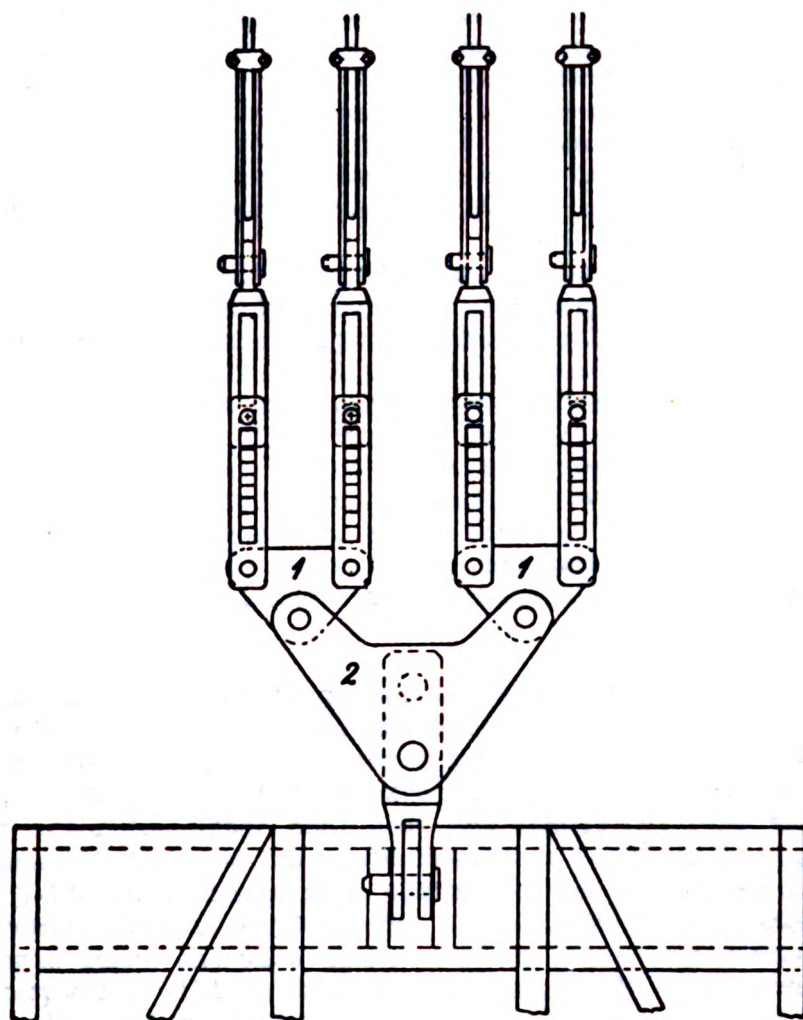


Figure 24. - Load equalizer for four-rope hoisting.

was capable of stopping and holding a fully loaded cage at any point in the shaft. Dial-type indicators show the positions of the cages at all times and are placed so they are in plain view of the hoisting engineer (fig. 21). Because of the depth of the shafts and the loads hoisted, the headframes are massive (fig. 23), and the average diameter of main hoisting ropes was 2-3/4 inches.

Except in a few "blind" shafts, the "Koepe" system of rope winding is used throughout western Germany. This system consists of a single rope that makes about two-thirds of a lap around the large sheave connected to the hoisting engine, and then is threaded over the headframe sheaves, and the ends of the rope are connected to the cages. The engine-room sheaves are 18 to 24 feet in diameter, and the grooves are about 6 inches deep. Aluminum inserts or wearing plates in the grooves prevent the ropes from slipping. A typical engine-room sheave for the Koepe system of winding is shown in figure 22.

The hoisting rope is attached to the cage by means of thimbles and clamps, and bridle chains usually provide a secondary connection between cage and rope. To counterbalance the weight of the hoisting ropes and cages, a single, flat-braided, steel-wire tail rope is suspended in the shaft around a tail sheave and connected at each end to the bottom of each pair of cages. An exact record of the length of service of each hoisting rope is kept, because mining regulations prohibit the use of a hoisting rope for more than 2 years without special permission. In instances where a new rope is not available and the time limit of service is reached, an official of the Mine Inspectorate, after subjecting an old rope to rigid tests, may grant an extension of time not exceeding 6 months. Additional time extensions also may be granted following similar tests.

A recent innovation in hoisting-rope installation was observed at one mine where the hoisting equipment was installed in the headframe directly over the shaft and employed four hoisting ropes connected to each of the two cages. The shaft was 2,500 feet deep, but is expected to reach an ultimate depth of about 4,500 feet after the upper coal beds are exhausted. The net load of each cage was about 12 tons, which would require a 2-3/4-inch single hoist rope; whereas a 3-1/2-inch single rope ultimately would be needed to hoist the same load from a depth of 4,500 feet. Consequently, four small ropes instead of a single large one were used. Each of these ropes was only 1.45 inches in diameter, which will be increased to only 1.85 inches when the 4,500-foot depth is reached. A mechanism to equalize the load between the four ropes was installed at the point where the ropes were fastened to the cages (fig. 24).

All cages operating in main hoisting shafts are of the multiple-deck type. The number of decks ranges from two to six, each deck having a capacity of from one to four mine cars. They are built with enclosed sides and adequate steel bonnets and are equipped with safety catches, handholds, and safety gates. The cages, ropes, fastenings, and other safety devices were examined daily for defects.

Many of the cage guides were worn excessively, but suitable replacement material was difficult to obtain. The normal coal-hoisting speed was about 3,400 feet a minute, but this was reduced at many mines where the cage guides were worn excessively. As many as 70 men were permitted to ride at one time on some cages, but the average number was 64; that is, 16 men on each deck of a 4-deck cage. An attendant was in charge at each cage landing, and the men conducted themselves in an orderly manner during loading and unloading. Generally, the shaft landings were arranged so that men could load or unload from two or more decks at a time. When men are transported, the speed of the cages is limited to 1,560 feet a minute, and tools and other equipment are not permitted on the cages with them.

Only about 12 skips were installed at Ruhr mines, because the operators complained that the degradation of coal was excessive when handled by skips. Those in use were about 10-ton capacity and were similar to skip-hoisting installations in the United States, except that the Koepe system of hoisting was used.

MISCELLANEOUS SURFACE CONDITIONS

Refuse Disposal

Only a few coal companies dispose of mine refuse on the surface, and then only when the operations are in outlying areas where surface subsidence is not considered important. Refuse for disposal on the surface was transported by lorries or conveyors. The refuse piles were enclosed by fences and so located as to avoid hazards from slides, fumes, and smoke. Only a few piles were burning, and the fires were not hazardous.

Surface Fire Hazards

Combustible structures are not erected within the plant yards, and the only combustible materials of any importance in the mine yards were the supplies of mine timber, which were stored at safe distances from mine openings. Ample fire-fighting facilities were available at each mine, consisting of fire extinguishers, a supply of water, fire hose, and fire hydrants. In most instances, the fire-fighting equipment of municipal fire departments also was available.

UNDERGROUND MINING METHODS AND PRACTICES

Virtually all coal mines in the Ruhr district employ the advancing system of longwall mining. Generally three levels are mined concurrently in definite sequence so that as the uppermost level nears completion the next lower level is fully developed and in full production and the second lower level is just being developed. About 98 percent of the coal is recovered. As stated previously in this report, only two shafts are customarily sunk when a mine is started; one is used as an intake airway and main hoisting shaft and the other as a return airway. Many mines, however, are connected underground with other mines, and certain shafts are used to the best advantage for all concerned. At some mines, hoisting operations are performed in both intake and return air shafts.

Haulageways and Airways

Main haulageways and airways generally are driven through rock and at right angles to the strike of the coal beds at different levels in the strata, and the distance between them generally is governed by the faults and the desired length of longwalls. The uppermost level serves as the main return airway, whereas each succeeding level serves as the haulageway and intake airway for the coal beds directly above it. Supplies and packing material generally are transported through the level above the faces to be served. Haulage connections between levels are made by "blind shafts"; that is, shafts connecting levels but not connected directly with the surface.

Generally, the haulageways are developed from the shaft in the direction of the boundaries of the area to be mined; however, the occurrence of anticlines, synclines, faults, and the workings of other mines sometimes necessitate deviations from the general practice. Side entries off the main haulageways (commonly called "gate roads") generally are driven on the strike in the coal beds, and the longwall faces extend from one side entry to the corresponding side entry in the adjacent level. The face of the lower gate road is seldom more than 30 feet in advance of the longwall face, but some of the upper gate roads were fully developed during previous mining. The width and height of entries usually are governed by ventilation requirements rather than by the space needed for haulage purposes. The available cross-sectional area of main entries inside the timbering is about 200 square feet, and the cross-sectional area of side entries is about 60 square feet.

Longwall Faces

The length of a longwall face is governed principally by the faults, inclination of the coal bed, and daily production desired from that face. Generally, the faces in steeply pitching beds are considerably shorter than those in flat beds. The tendency is to have as long a face as possible; however, both long and short faces have certain disadvantages. Short faces require the development and maintenance of more roadways for a given output than long faces; moreover driving and maintaining roadways are among the most expensive items coincident with mining in the Ruhr. Development of longer faces in the steeply pitching beds has the disadvantage of requiring transportation of packing material for greater distances, as caving is impracticable in such beds. An important disadvantage of a long face is manifest with a breakdown of failure of face equipment because the effect on production is greater than with shorter faces. Although the longwall faces are advanced in the direction of the strike of the coal beds, those in steep or semi-steep beds are inclined at suitable angles to regulate the rate of flow of the coal.

Faces in steeply pitching beds range from 150 to 700 feet in length and generally are advanced as diagonals between the strike and the pitch, so that the inclination of the face with the horizontal coincides with the angle of repose for the packing material. The average length of all longwall faces is 650 feet; however, 1,300-foot faces were not uncommon; a few were nearly 2,000 feet long, and one face was 3,600 feet long. The lower end of a steeply pitching longwall face is generally advanced ahead of the upper end, and the entire

face is advanced in a series of short steps. The width and depth of the steps are determined by several factors, such as the thickness of the coal bed, the nature of the roof and floor, the rate of advance of the face, the proximity and rate of advance of adjacent faces, and the amount of packing material available. The number of steps worked on a face ranges from 1 to 30. On some longwalls, the short steps of face are advanced in the direction of the inclination of the longwall face. Where short steps are advanced in the direction of the strike, one (in a few instances, two) workman is assigned to a given step of a face, which he continues to work throughout the life of the longwall. On short steps of face worked in the direction of the inclination of the face, each miner in turn starts a step of a face at the top end and advances it until it is completed at the bottom end; he then returns to the top end and starts a new step. Each miner is assigned a given rate of advance for his step of face per shift, which is governed by the thickness of the coal bed, the nature of the coal, roof, and floor, and the pitch of the bed. The average rate of advance of a longwall face was about 4 feet per shift. Sketches of typical faces in steep beds are shown in figures 25, 26, and 27.

Barrier Pillars

Barrier pillars are not left along the haulageways, regardless of the inclination of the coal bed or the length of the longwall. Where barrier pillars are left for the protection of shafts and surface installations, their dimensions are prescribed by the Mine Inspectorate. Unless unusual conditions exist, standard-size barriers are prescribed; they consist of an area circumscribed by an angle of 30 degrees with the vertical of the collar of the shaft or other surface installation to be protected. However, some mines are operated beneath such densely populated and industrialized areas that the coal reserves outside the prescribed barriers comprise less than 20 percent of the total within the boundaries of the mine property. To justify the sinking of shafts and equipping mines in these areas, a system of mining known as the "harmonic" method was adopted in which barrier pillars are not required and all the coal is recovered. In the harmonic method complete mining of coal precedes the sinking of a shaft to lower levels so that the entire area within the shaft zone has subsided from mining according to a predetermined sequence; therefore progressive shaft sinking is accomplished in caved ground. This method was a comparatively recent innovation and was being watched closely by mining men throughout the Ruhr.

On longwalls where full-caving is not employed, the roof in the mined areas is supported by various methods of backfilling; generally, however, the backfill in important areas consists of pack walls built of stone set solidly in place by hand. The pack walls along the gate roads (levels) are generally about 30 feet wide and are built as the entries are advanced.

Hand Mining

Approximately 13 percent of the output of the Ruhr was undercut with mining machines, 6 percent was shot "off the solid," 3 percent was mined by coal plows, 1 percent was mined with cutter loaders, and the remaining 77 percent was mined with percussion picks. The percussion picks resemble and are operated similarly to "jack hammers" and pavement breakers used in the United

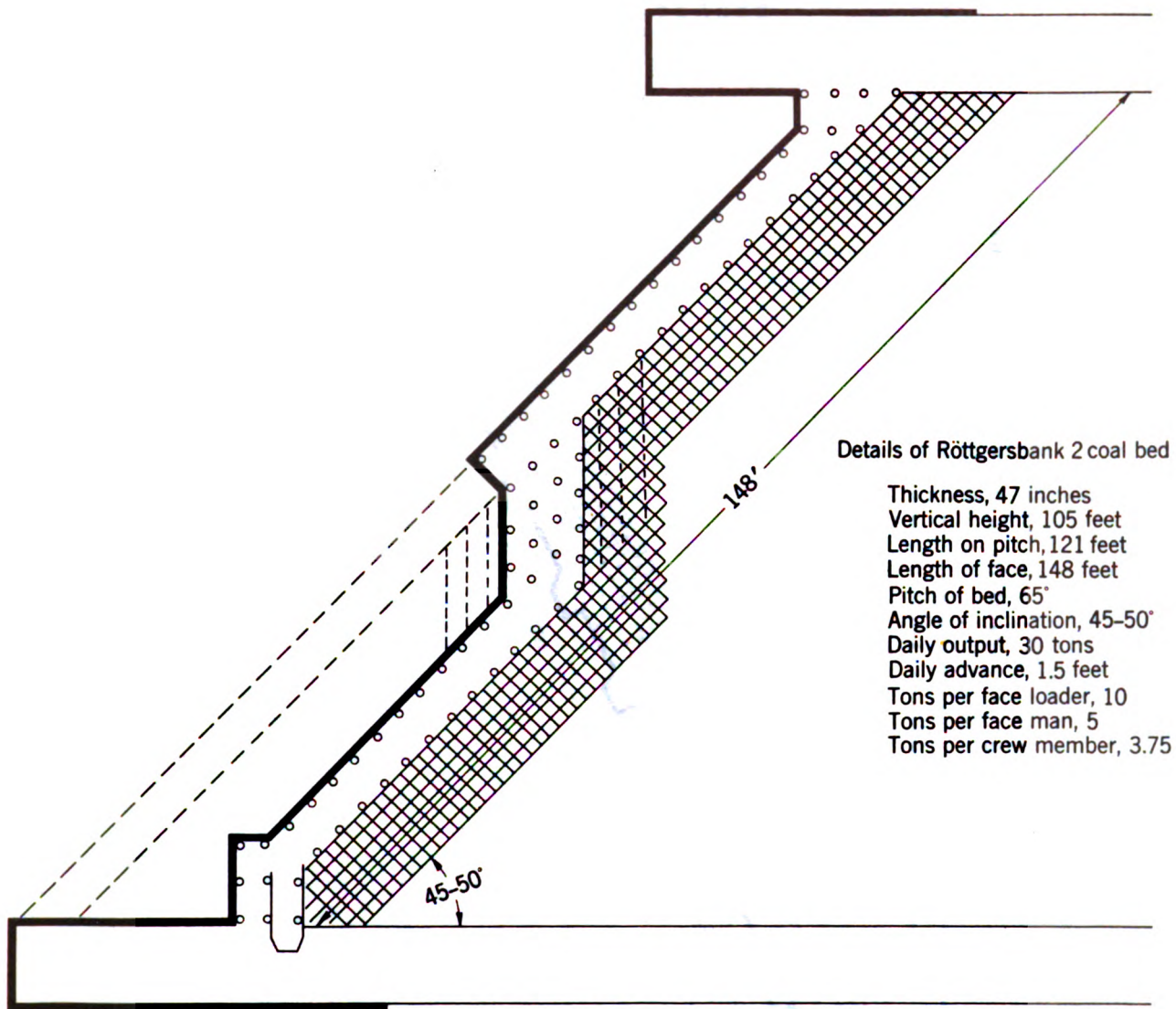


Figure 25. - System of mining, steep pitches.

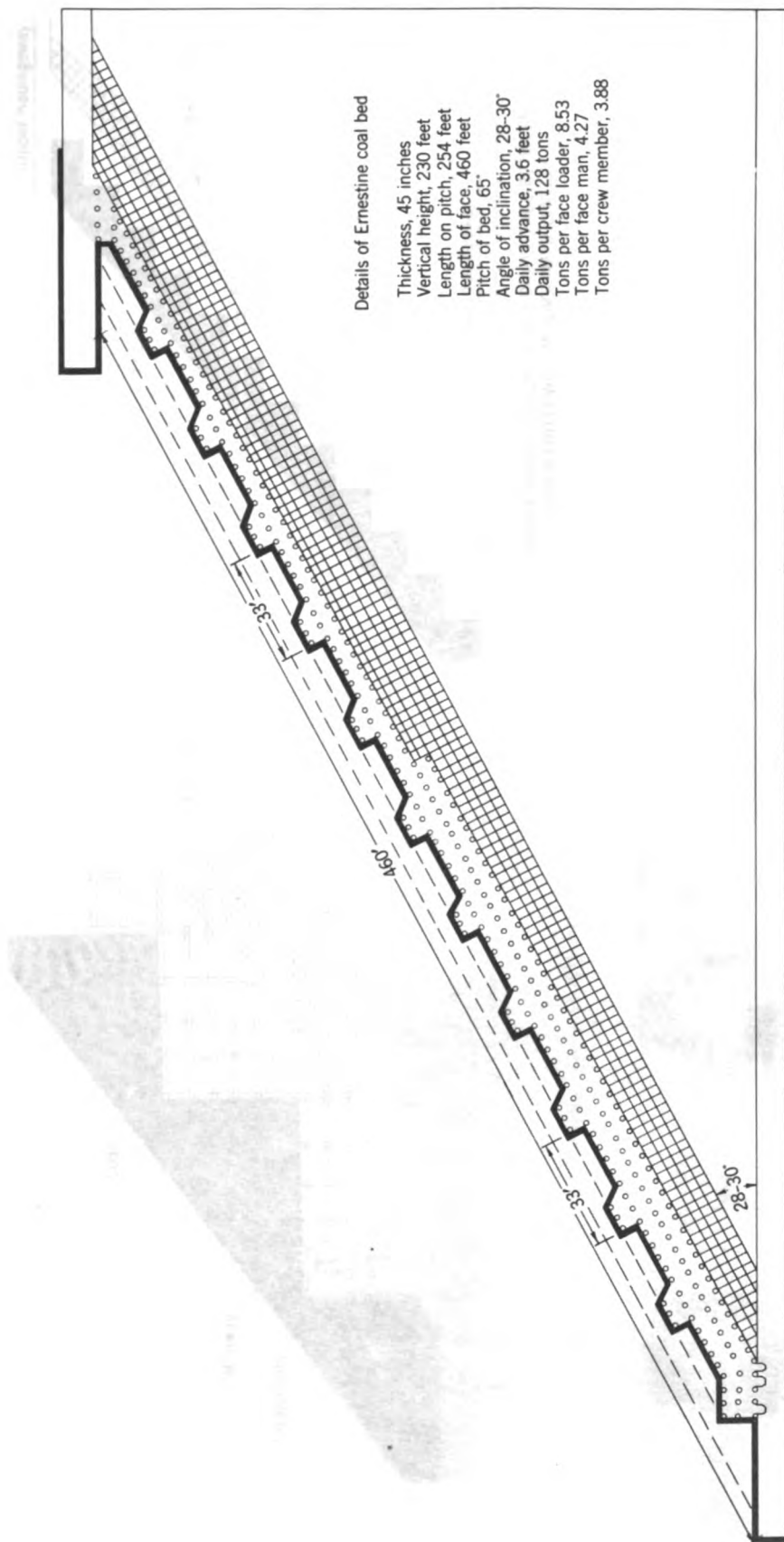


Figure 26. - System of mining, steep pitches.

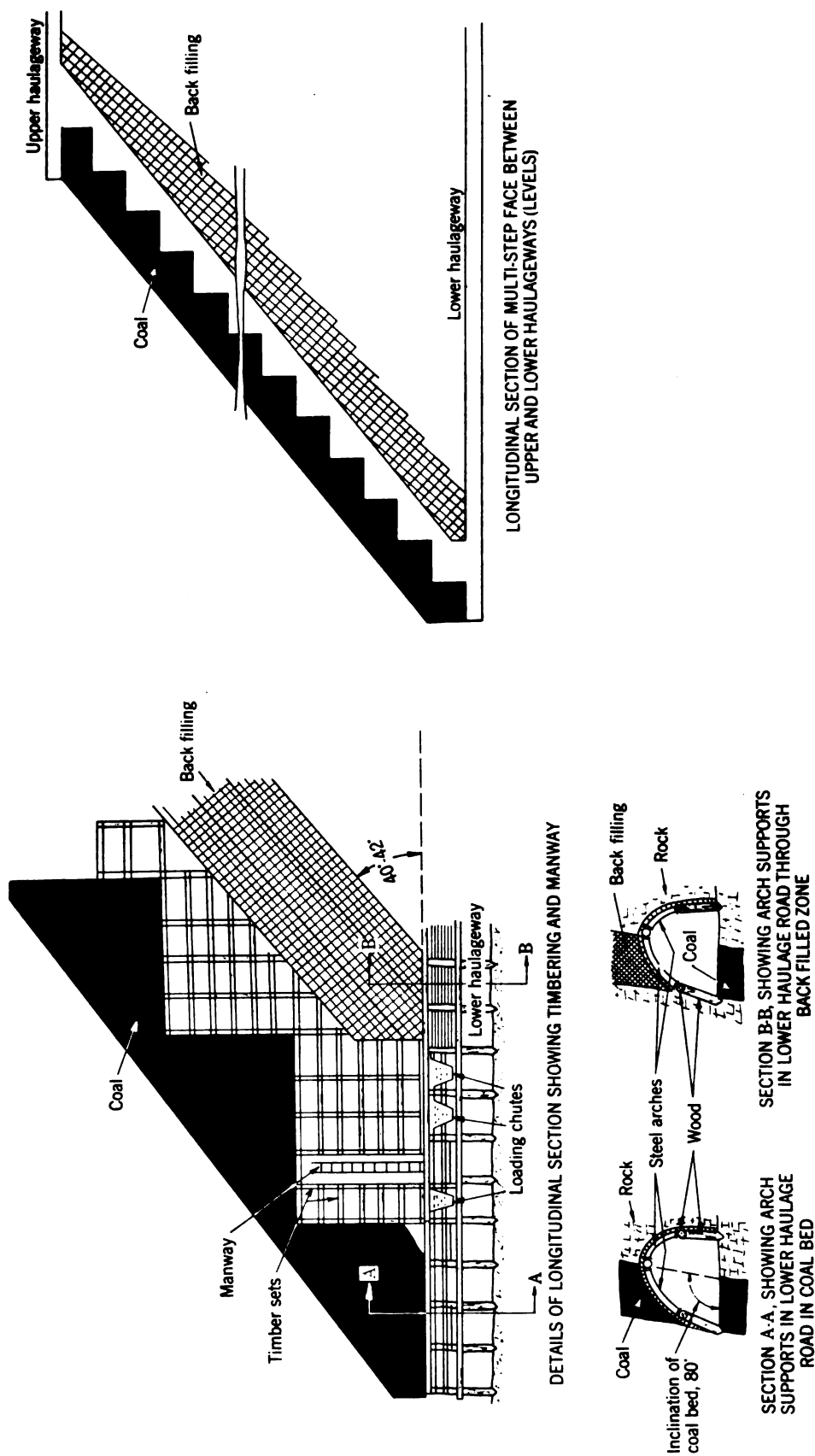


Figure 27. - Multistep face in steeply (80°) pitching bed.

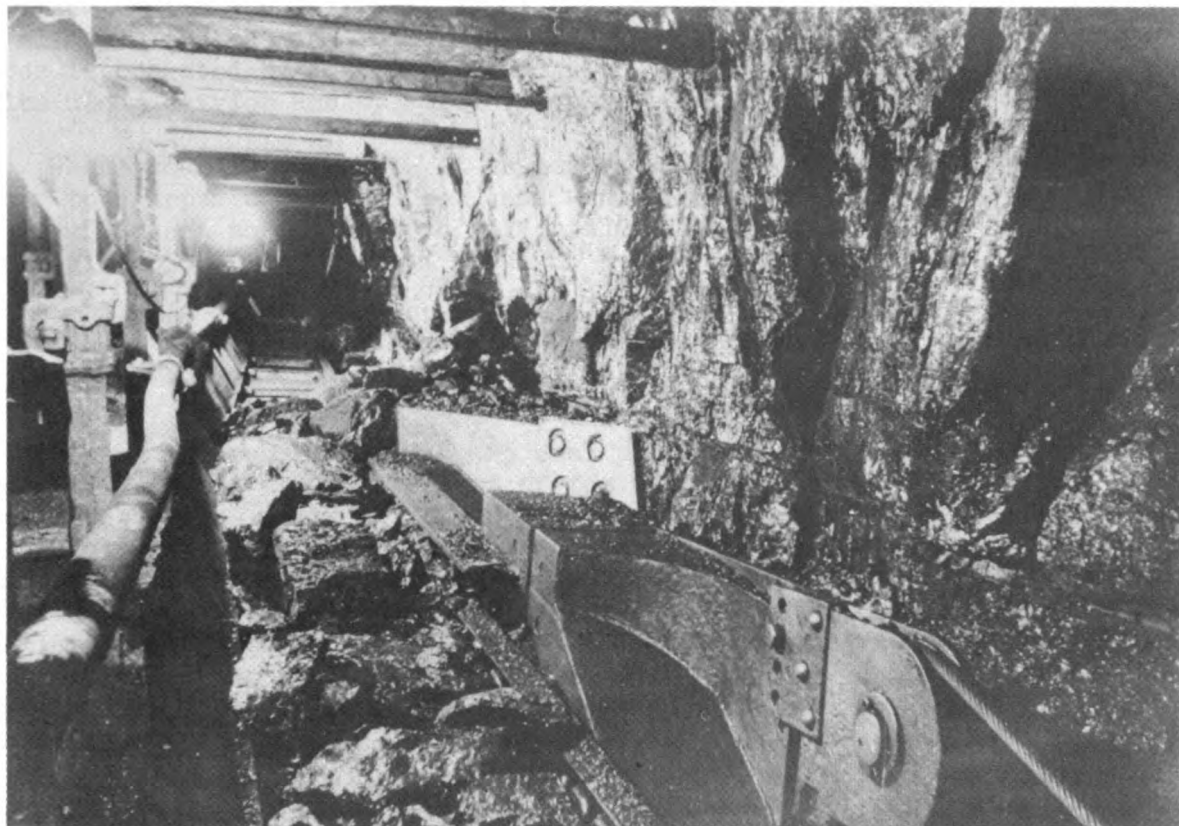


Figure 28. - Coal plow (Kohlenhobel) produces reasonably coarse coal.

States. They weigh about 20 pounds each, the bit is about 20 inches long, formed to a pick point, and ordinarily the pick is operated at an air pressure of about 60 pounds per square inch. Each miner was equipped with a pneumatic pick and was responsible for its safekeeping.

The coal loosened from the faces by the miners either flows by gravity to the loading point or it is loaded onto conveyors by hand. Where conveyors are used along the face, the inclination of the coal bed rather than its thickness determines the type conveyor to be used. Double chain-and-flight, belt, or shaker conveyors ordinarily are installed in flat workings, whereas in steep or semi-steep workings disk-type rotating conveyors, double-chain conveyors, or fixed chutes generally are used; and in some instances the coal is permitted to slide on the packing material. Most of the mechanical equipment along the faces is operated by compressed air, although a few face conveyors and some belts along entries are operated by approved-type electric devices.

Where coal is undercut, it is generally done about 12 inches above the floor to a depth of 5 or 6 feet, and when pressure from the overlying strata is insufficient to cause it to fall, it is either blasted or dislodged with percussion picks.

Mechanical Mining

Coal Plows

During the summer of 1948, 25 coal plows were in operation in the Ruhr, and they produced about 3 percent of the total output. The coal plow (Kohlenhobel) was designed for use in flat coal beds; however, variations of the original design permit its use in semi-steep beds. For instance, in one mine experiments were conducted in a coal bed that pitched 75 degrees and with the face advanced along an inclination of 42 degrees from the horizontal. The latest modification of the coal plow requires no workers or timbering at the face. When the authors investigated this machine, it had been operating for 2 months along a 300-foot face in 40-inch coal and was producing 160 tons a shift.

The standard coal plow (fig. 28) is very simple in construction. It is actually two plows joined together, so that cutting can be done on either the forward or return stroke. A joint between the two plows permits some vertical movement to allow for irregularities in the floor. Horizontal movement at the joint between the plows is not provided, because experience has proved that such movement is undesirable. The plows have no moving parts except for the joint between two plows, and such plows are equipped with activated picks. Various shapes, sizes, and angles of the cutting blades are employed to conform with the nature of the coal, roof, floor, and thickness of the coal bed. The basic principle and design of the coal plow, except for those equipped with activated picks and those used in steeply pitching beds, have been standardized, and two sizes are in general use. The smaller plow, for use in coal up to 4 feet thick, is 16 inches high, 20 feet long, 24 inches wide, and weighs about 3 tons. The larger plow, for use in thicker coal beds, is 24 inches high, 22 feet long, 28 inches wide, and also weighs about 3 tons. Most of the plows produce reasonably coarse coal.

The coal plow is drawn along the face with ropes powered by hoists in the top and bottom gate roads. Two hoists in tandem are used in each of the gate roads to draw the plow back and forth across the face. One of the hoists in each gate road has three to four laps of rope around its drum and serves as the pulling hoist, whereas the other serves as the rope-storage hoist. As the coal plow is drawn back and forth along the face, the cutting blades engage the coal face, and the opposite side of the plow, which is fitted with a slide or shoe throughout most of its length, slides along the side of a double-chain-flight conveyor. The conveyor forces the cutting blade of the plow against the coal face because the conveyor itself is being pushed continuously toward the face with pneumatic jacks, sliding wedges, or ratchets set between it and props that support the roof (fig. 29).

The conveyors used along a coal-plow face must have not only a large capacity but must also be capable of withstanding lateral pressures of at least 2 tons. This is because the force necessary to hold the plow into the face is transmitted through the conveyor. The shaking conveyor is the most common type conveyor in use in the Ruhr, but it is not suitable for coal-plow faces. The armored-type double-chain-flight conveyor with bottom return meets the requirements for low height and strength necessary for coal-plow faces. However, the principal difficulty with this conveyor is its high power requirement. Many tests and experiments were conducted with armored conveyors, and during 1948 experiments were conducted with rolling rather than sliding cross bars between the chains.

Scraper Loaders

A typical example of scraper loading was observed at a mine near Recklinghausen. This scraper was operated by compressed air and was used along a 300-foot face where the coal bed was nearly level. The installation consisted of four boxes connected in tandem to a 1-1/2-inch endless rope and spaced about 80 feet apart. Each box was 32 inches wide, 14 inches high, and 12 feet long. The top, bottom, and one end were open, and the closed end of each box was fitted with a gate that opened in only one direction. The corners of the boxes were equipped with teeth or cutting edges, each one about 2 inches wide and spaced 1-1/2 inches apart. A guide rail along the floor, installed parallel to the face, kept the boxes against the coal. Such rails weighed about 70 pounds per yard and were forced against the boxes by compressed-air jacks spaced about 15 feet apart. Motive power to operate a scraper loader was supplied by an 80-horsepower compressed-air motor installed in the entry and operated at a pressure of 65 pounds per square inch. The pull on the rope was about 12 tons. In operation, each box traveled about 100 feet in each direction cutting out thin slices of coal as it moved. These slices were about 2 inches deep and 14 inches high, but the total depth of the undercuts seldom exceeded 8 inches before roof pressure caused the overhanging coal to fall. As the boxes were spaced 80 feet apart and each one traveled about 100 feet before its direction of travel was reversed, there was an overlapping of about 20 feet in the course of adjacent boxes; thus, each box discharged its load at its farthestmost point of travel toward the loading point, and the load was picked up by the next outby box after its direction of travel was reversed at its maximum point of travel away from the loading point. The first box of the series of boxes discharged its load onto a belt conveyor, which, in turn, discharged into mine cars.

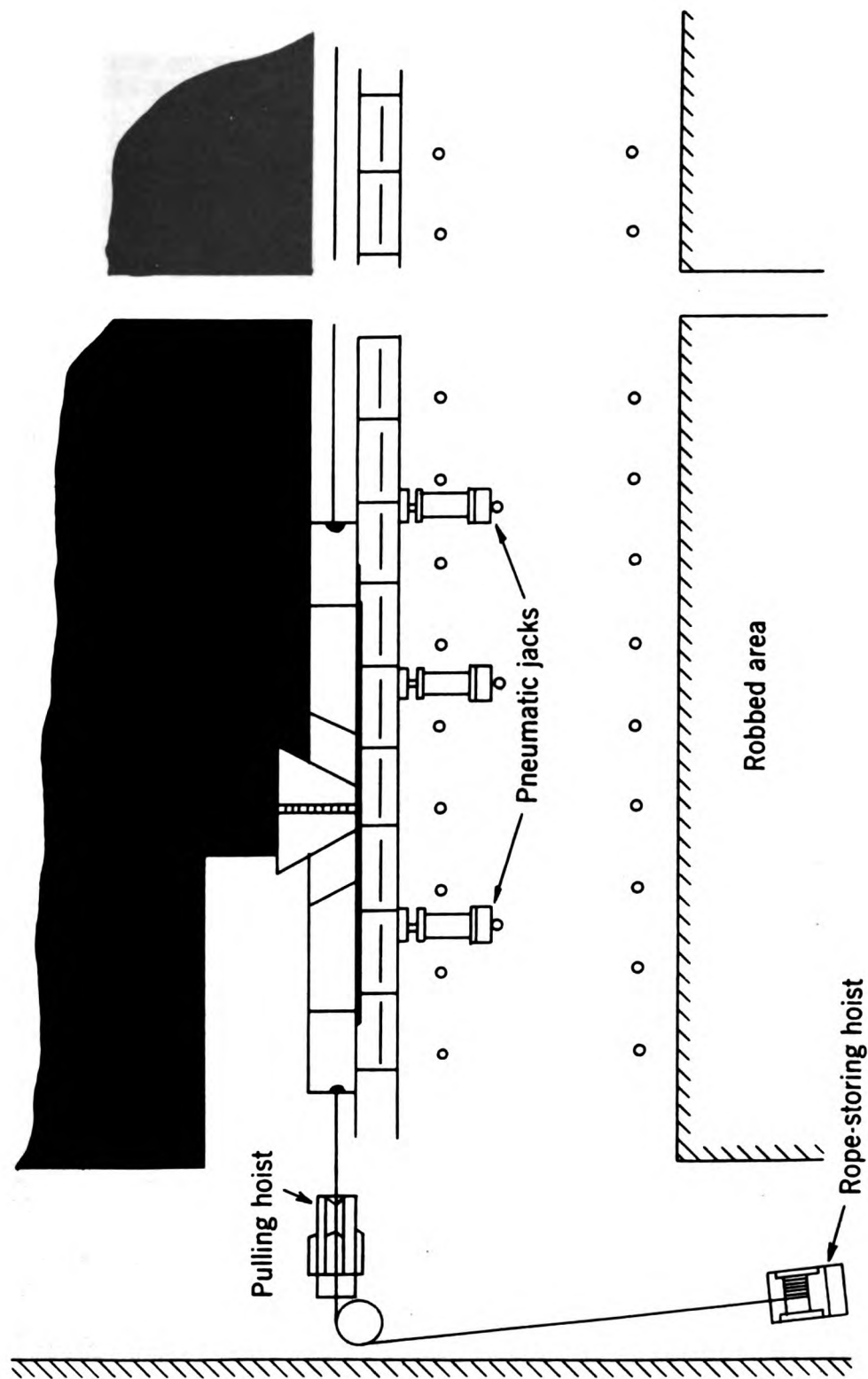


Figure 29. - Arrangement of hoists and pneumatic jacks for coal plow face.

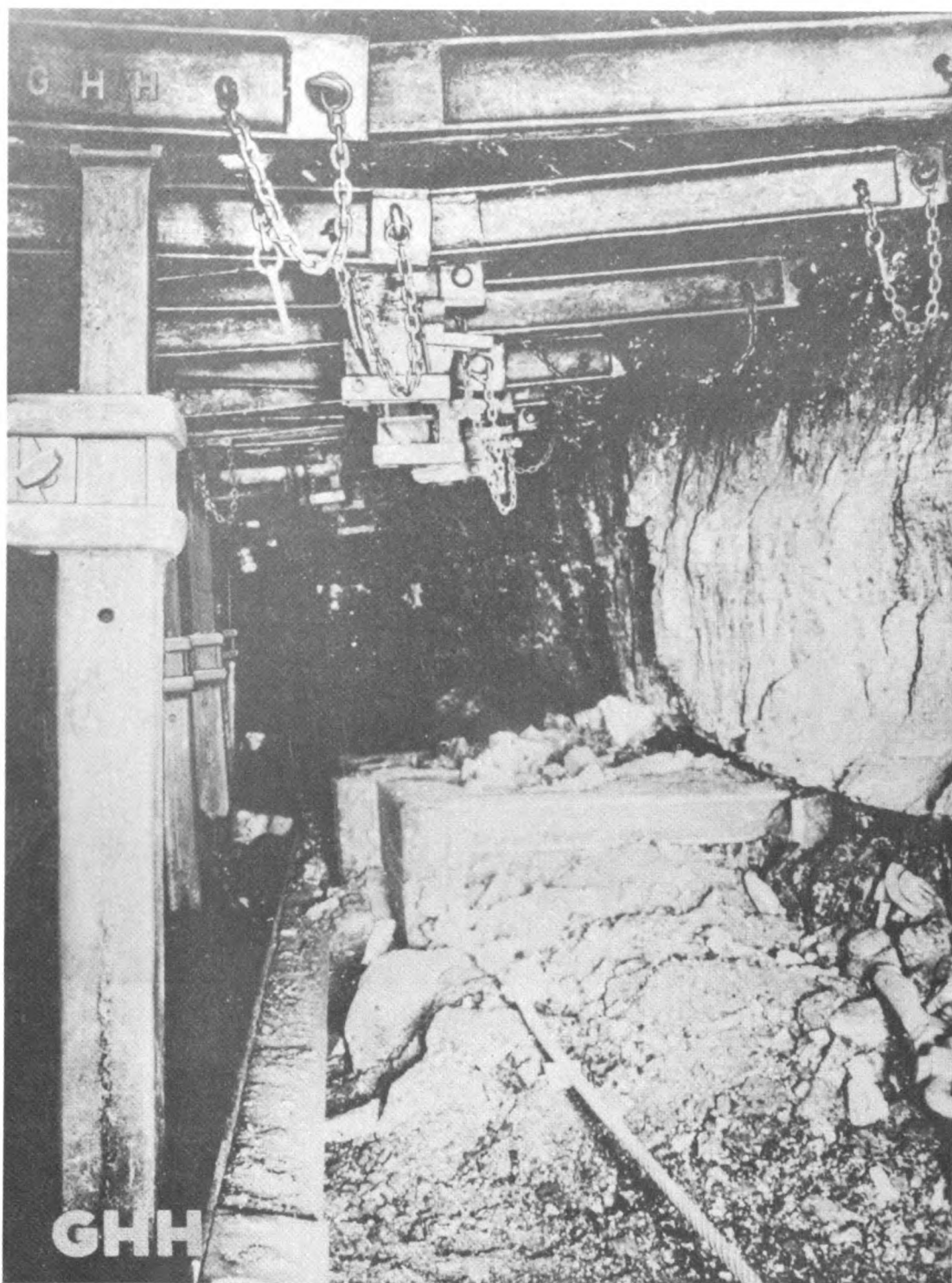


Figure 30. - Typical scraper loader with extensible-type crossbars.

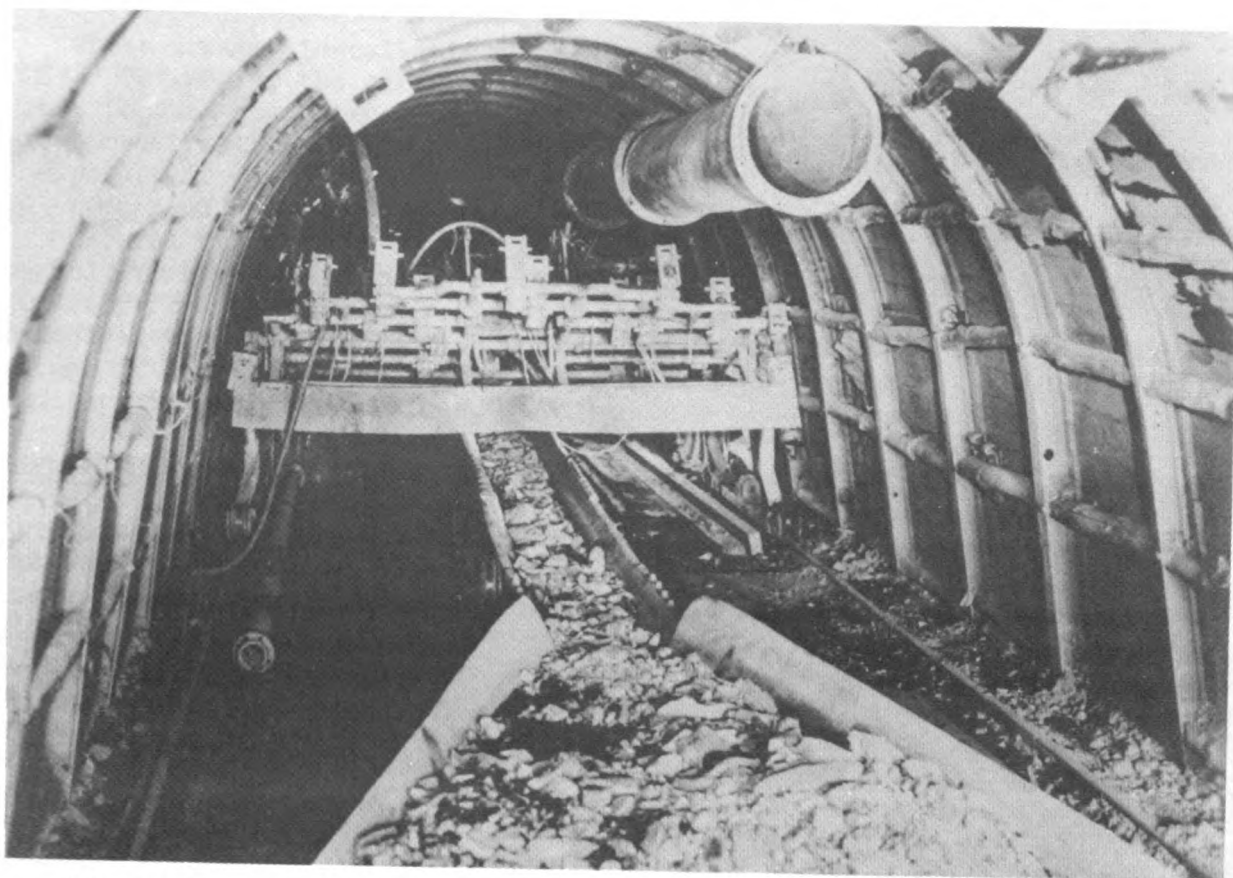


Figure 31. - Duckbill entry loader in entry with steel arch supports.

A similar example of scraper loading (fig. 30) was observed at a mine near Kamen where the face was longer than at the previously described mine and six scraper boxes were used. The boxes were slightly smaller and were equipped with cutting edges only on the sides adjacent to the face. The cutting edges were so arranged that about a 7-inch cut 2 inches deep immediately above the floor was made on the loaded stroke and about a 14-inch cut 2 inches deep was made immediately above the first cut on the return or empty stroke.

Electric lights in vaportproof fixtures were installed about 25 feet apart along the face and at the hoisting engine, and approved-type control buttons at frequent intervals permitted transmission of signals by flashing the lights.

These scraper installations were producing 100 to 170 tons of coal a shift. Obviously, the systems produce more coal from thicker beds and longer faces, because a greater number of boxes can be connected to the rope. The system requires comparatively soft coal, however, and large sizes should not be expected from the thinner coal beds.

Several other types of combination cutting and loading machines for longwall work were in process of development. All of them were designed primarily for operation in relatively flat coal beds without the use of explosives to loosen the coal. Some of them are promising; however, the percentage of large-size coal will be small; consequently many operators are reluctant to use such machines.

Duckbill Entry Loader

This is a combination machine consisting of a duckbill and short chain conveyor attached to an elevating belt, and the entire machine is mounted on wheels for maneuverability (fig. 31). Used largely for entry driving, it has a loading capacity of about 1 ton per minute. The duckbill, which extends to full entry width, precluding side movement, discharges onto a short belt conveyor, which, in turn, elevates the material to the mine cars. The duckbill and propulsion winches are driven by two 16-horsepower compressed-air motors; the belt conveyor is operated by a single 6.5-horsepower compressed-air motor. The machine is 78 feet long, and the width depends on the duckbill construction, because these are changed at will as the entry width is changed. The machine is operated as an ordinary duckbill shaker-conveyor unit and is believed by the management of the mine to be entirely successful.

Roof Support and Backfilling

Kinds of Roof

The immediate roof over about half of the coal deposits in the Ruhr mines is shale; about 15 percent is sandy shale, and 35 percent is sandstone. Most of the overburden above the top coal bed consists of layers of free-running sands, clay, and marl. The marl, which is immediately above the coal measures, is generally impervious. The Ruhr mines are exceptionally dry in comparison with coal mines in the United States. Slips, pots, and horsebacks are frequent in shale roof, and faults are common throughout the region. Generally, the floor is fairly firm and reasonably smooth.

Roof Support in Entries

All entry timbering is done according to plan and, although the systems at various mines differ in minor details, the over-all plan is much the same throughout the field. Main haulageways and airways are driven in solid rock, and the roof and sides are generally supported by steel arches on close centers; however, wooden props are used along a few permanent haulageways where extreme pressures are not likely to occur (fig. 32). Round wooden timbers 2 to 4 inches in diameter are used as lagging at the top and sides, and the space between the lagging and the walls of the entry is hand-packed solid with stone. Some of the steel arch segments are bolted or riveted in place, but most of them are fastened together with friction clamps that permit some subsidence without distorting the arches. In extreme cases, where the pressure causes the floor to heave, the arch segments are extended to form complete rings in the entries.

Brick or concrete arches often are used to support the roof and sides in the vicinity of shaft landings and at other places where the cross-sectional area is unusually large (fig. 33). Where either is used, an occasional layer or course of wood about 4 inches thick is inserted to permit some compression without breaking the walls. Generally, the brick or concrete walls are 4 to 5 feet thick.

Face Timbering

The system of roof support at longwall faces differs according to the inclination of the coal beds. Where the inclination is less than 30 degrees, steel supports are used when available. Wooden supports are used in places inclined more than 30 degrees. Several models of collapsible-type steel props were available and appeared to give satisfactory results. One of the popular models (fig. 34) was designed to withstand a 60-ton load before slipping. It was constructed essentially as follows: The outer member is formed to a box shape by welding two channels together. The inner member is I-shaped and is adjusted to the thickness of the coal bed and clamped by means of friction blocks in the webs. Pressure against the friction blocks is obtained through the use of a steel wedge and an eccentric cam. The friction blocks and the web of the inner member are coated with aluminum.

Steel caps or crossbars are generally used over steel props. These are made in various lengths, with the ends so constructed that they may be coupled together to form rigid crossbars of any desired length (fig. 35). Weak roof between parallel cross bars usually is supported by 2-inch round or split wooden poles over the cross bars and at right angles to them; these poles are generally spaced about 6 inches apart (fig. 36). Steel wire ropes are used instead of solid crossbars along the faces in some mines where the roof fractures in long slabs parallel to the face. Apparently, the system was giving satisfactory results. When wooden props are used in coal beds inclined more than 40 degrees, the foot of each prop is generally hitched into the floor or wooden footer so that men can stand or lean against the prop and work in safety. In places where the inclination of the coal bed exceeds 60 degrees, men work while standing on the props as on the rungs of a ladder. Split props are not used. Steel or wooden cribs are used where the roof pressure is unusually great; they usually are erected on piles of fine coal to facilitate their removal and recovery as the faces advance.

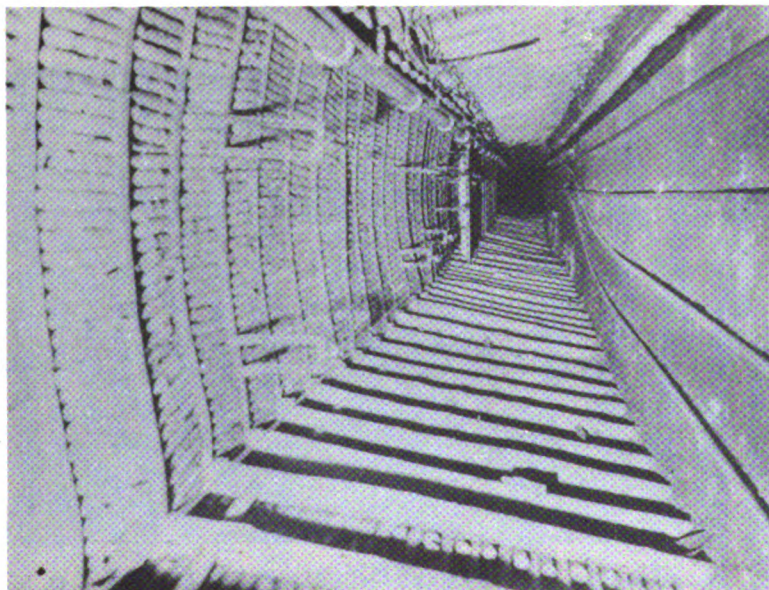


Figure 32. - Main haulageway, showing steel crossbars with wooden legs and lagging, and rock-dust barrier.

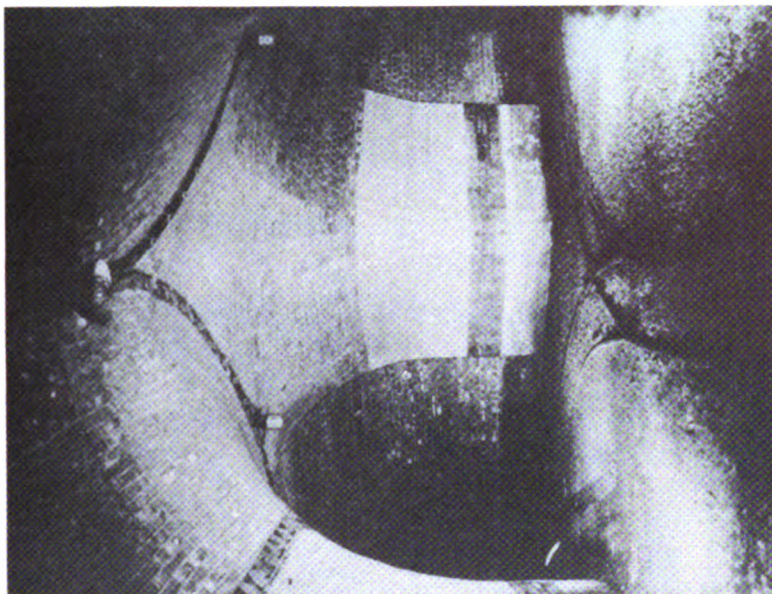


Figure 33. - Brick arches support roof and sides at wide places.



Figure 34. - Commonly used adjustable steel props.

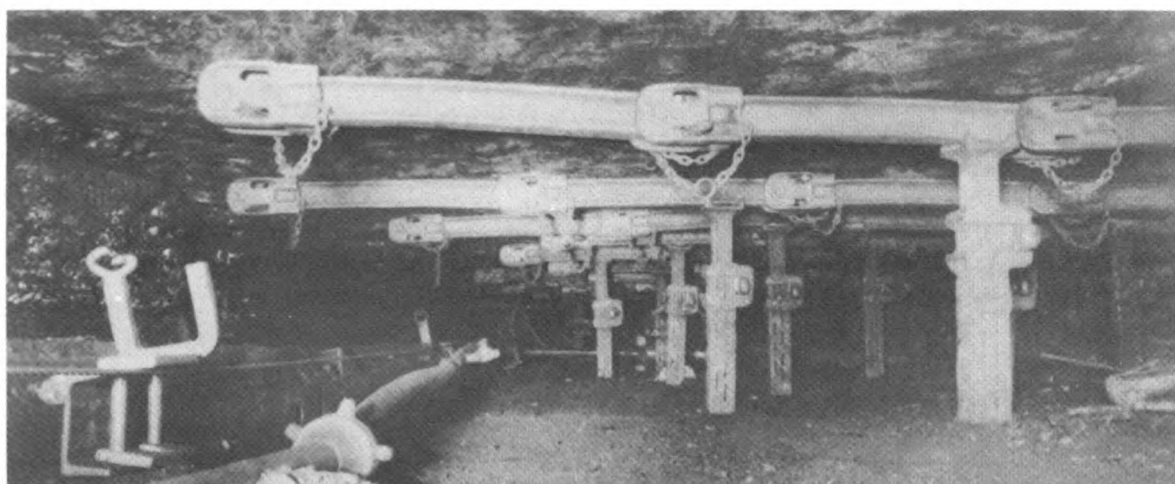


Figure 35. - Extensible crossbars.

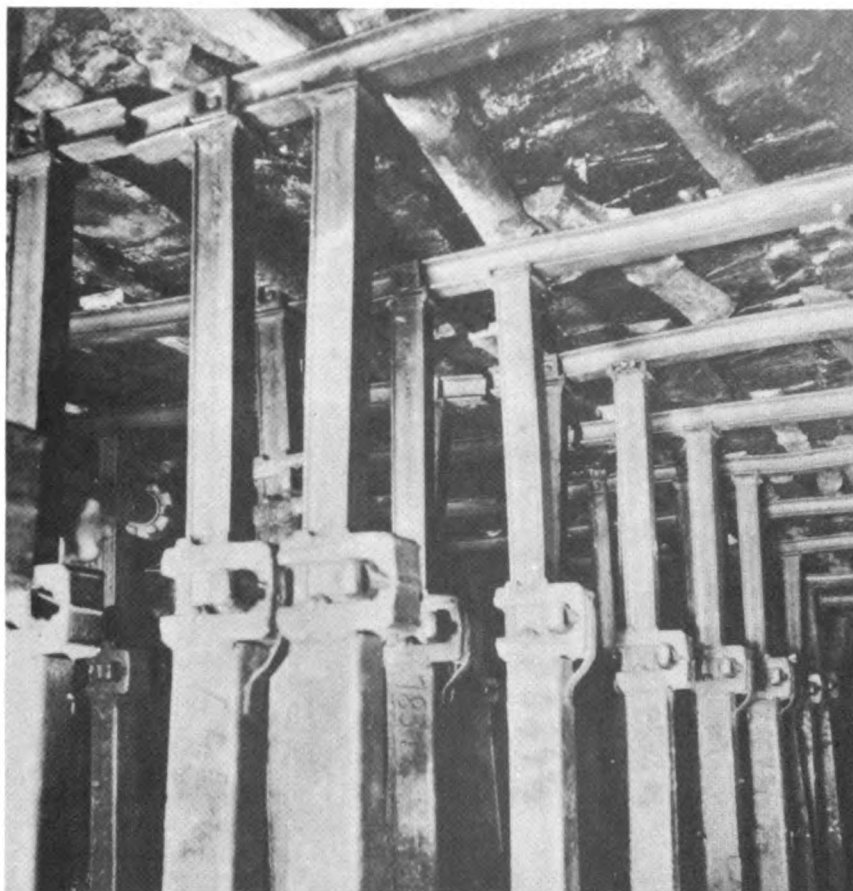


Figure 36. - Roof support between crossbars (note numbers on props for inventory purposes).

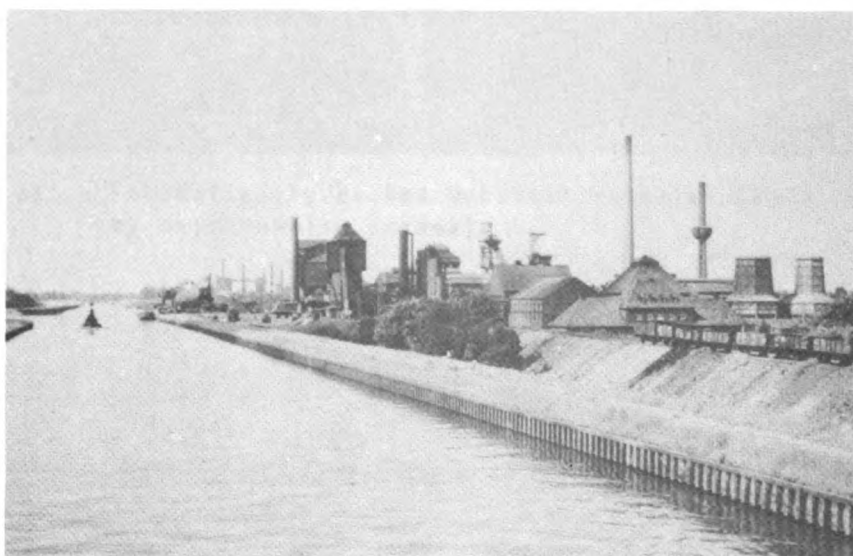


Figure 37. - Surface subsidence must be regulated in such areas.

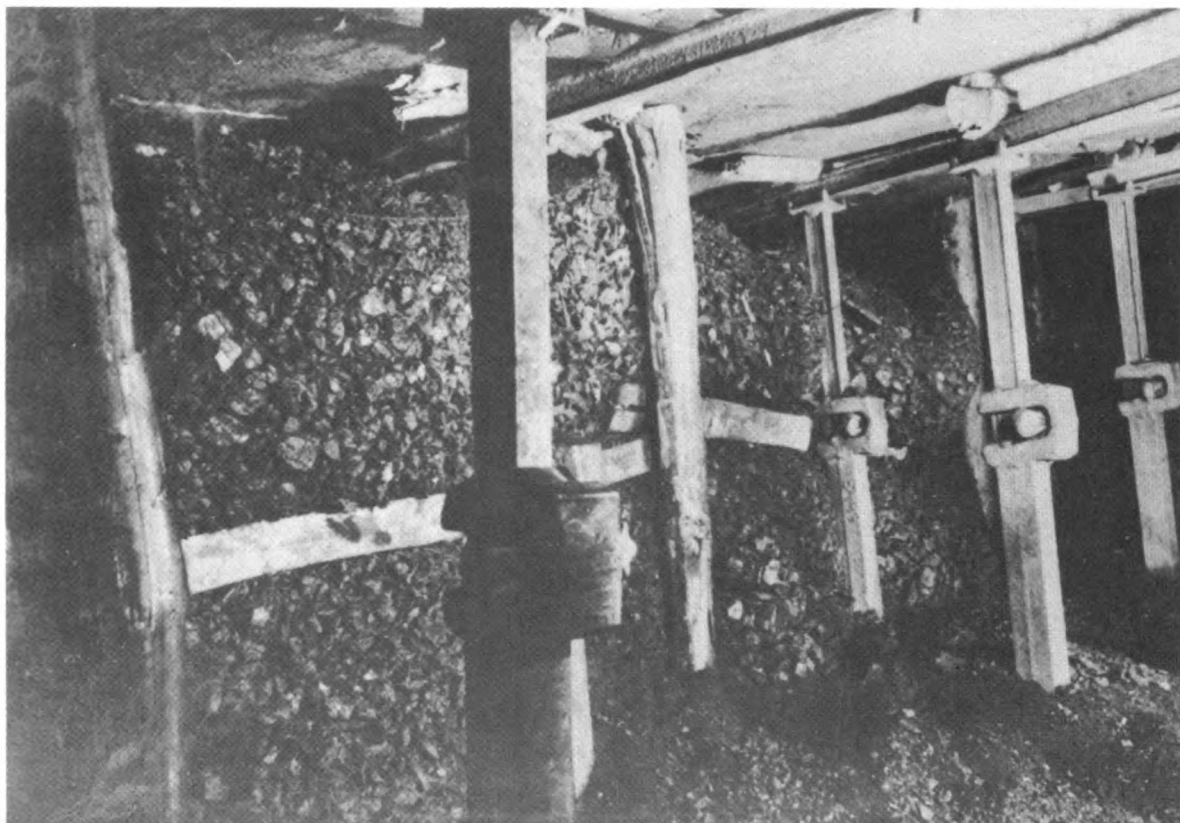


Figure 38. - Pneumatically packed backfill material (held in place by chicken-wire screen).

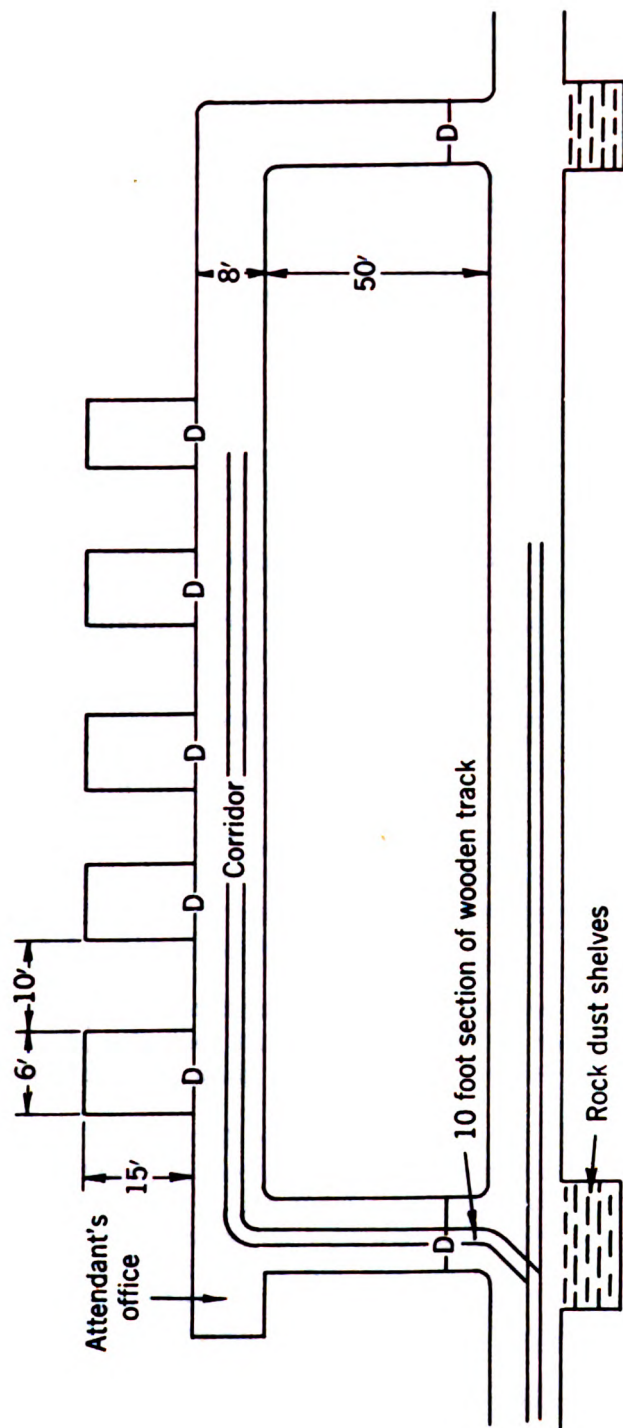


Figure 39. - Lay-out of a typical underground explosives storage magazine.

An effort is made to recover all steel that is used to support the roof, but recovery of wooden props is not attempted. The mining law requires setting props on centers not exceeding 39 inches in all directions. Little difficulty is experienced in removing steel props, and very few of them are lost. One operator of several mines said his steel-prop loss averaged less than 1 percent a year.

Generally, the regulations governing the setting of props were well carried out; nevertheless, accidents due to falls of roof or coal were frequent, particularly in places where the roof appeared to be sound. Mine officials and workmen are expected to examine the roof frequently, but as in mines everywhere the rule is often neglected. Examinations of the roof are usually visual, as the use of testing bars is virtually unknown.

Backfilling

The backfilling of mined-out areas is a general practice where the coal-bed inclination is greater than 25 degrees. Only about half of the mined areas in so-called flat beds are backfilled, and the full-cave system is followed.

The two principal reasons why backfilling is done so extensively in the Ruhr are (1) lack of space for storing mine refuse on the surface and (2) to reduce surface and adjacent strata subsidence after the coal is extracted. The surface above the Ruhr coal beds is densely populated, and the workings of several mines are under large cities, rivers, canals, and railway lines (fig. 37), and any damage to other interests caused by mining operations must be paid for by the coal companies. The break line of subsidence in the Ruhr is about 75 degrees with the horizontal.

Several methods of backfilling are in general use. Some of the material is packed in place by hand, some is dumped where it will flow by gravity to the desired places, some is forced by compressed air through tubes, and some is thrown into place by slinging machines.

Solid packing by hand permits the least subsidence (about 15 percent of the coal-bed thickness) at the surface, but it is an expensive method, and enough suitable material for such packing is difficult to obtain.

Packing or backfilling with washery refuse or crushed stone is said to be the least expensive method, excepting the full-cave method. When the coal beds are inclined sufficiently, as they do in about 25 percent of the places, the backfill material has merely to be dumped in the upper gate roads, from whence it will gravitate into the mined-out area. In less steep places, however, the backfill material is generally blown by compressed air in pipes and held in place by wire screens, as shown in figure 38.

In a few instances where belt conveyors are used along the faces, backfill material is unloaded from the belt onto a short high-speed conveyor, from which it is thrown with considerable force into the mined-out area.

Accurate costs of backfilling could not be obtained; however, several operators of coal mines in Germany agreed that the average total cost of backfilling would just about equal the cost of mining the coal.

Explosives, Detonators, and Blasting Devices

All explosives used underground are of the sheathed type and are approved by the Mine Inspectorate; each kind of explosive is subjected to rigid tests before approval is granted. Large quantities of explosives are used for blasting rock in haulageways and airways, but relatively small amounts are used for blasting coal. It was estimated that less than 6 percent of the coal produced in Germany is blasted.

Storage of Explosives

Explosives are not stored on the surface at mines in Germany, because in most instances suitable places for storage magazines are not available on the surface; therefore, explosives-storage magazines are constructed underground. Invariably, the spaces for these magazines are blasted from solid rock within 1,000 feet of the main haulage shaft landings and convenient to the main haulage tracks. A separate room is provided for each kind of explosive, and the rooms are lined with either brick or concrete. A steel door is erected at the entrance to each room and at the main portals of the magazine, and only one person, the authorized attendant on duty, is permitted to have a key for the magazine door. The cases of explosives are stacked far enough from the walls and from each other to permit free circulation of air, and each of the explosives compartments contains screened ventilator tubes or vents. Each electric light along the corridor giving access to a magazine is of the vapor-proof type. As an additional precaution, comparatively large rooms are excavated directly across the entrance passageways of the magazine, and these rooms are filled with tiers of rock-dust-filled shelves (fig. 39). An accurate record is kept of all explosives delivered to and taken from the magazines.

Delivery of Explosives

Explosives are delivered to the storage magazines during the off shift or on Sundays when only a few men are in the mine. The supply for each working place is carried by men who walk. The individual containers used in transporting and storing explosives underground are constructed of thin metal, about 20-gage, and are divided into two compartments for separating explosives and detonators. These boxes, which are carried easily by one man, are fitted with locks but are not lined with insulating material.

Blasting Practices

The decision to blast coal does not rest solely with the management of a mine. When the mine management decides that blasting of coal is necessary, a request is made to the Mine Inspectorate, which then sends an inspector to make a careful investigation of the circumstances. Before permission to blast coal is granted, the mine management must agree to comply with all the special recommendations made by the inspector. Each request is treated as a separate

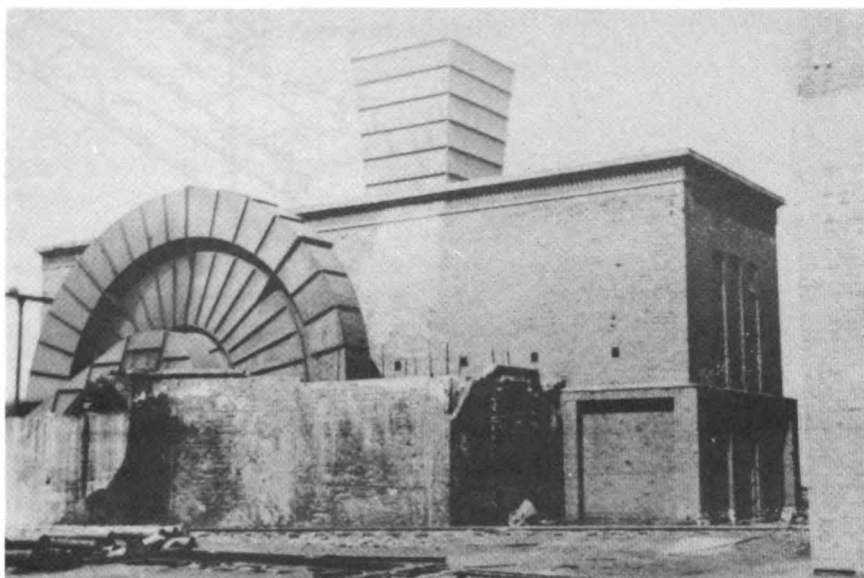


Figure 40. - Typical mine-fan installation.

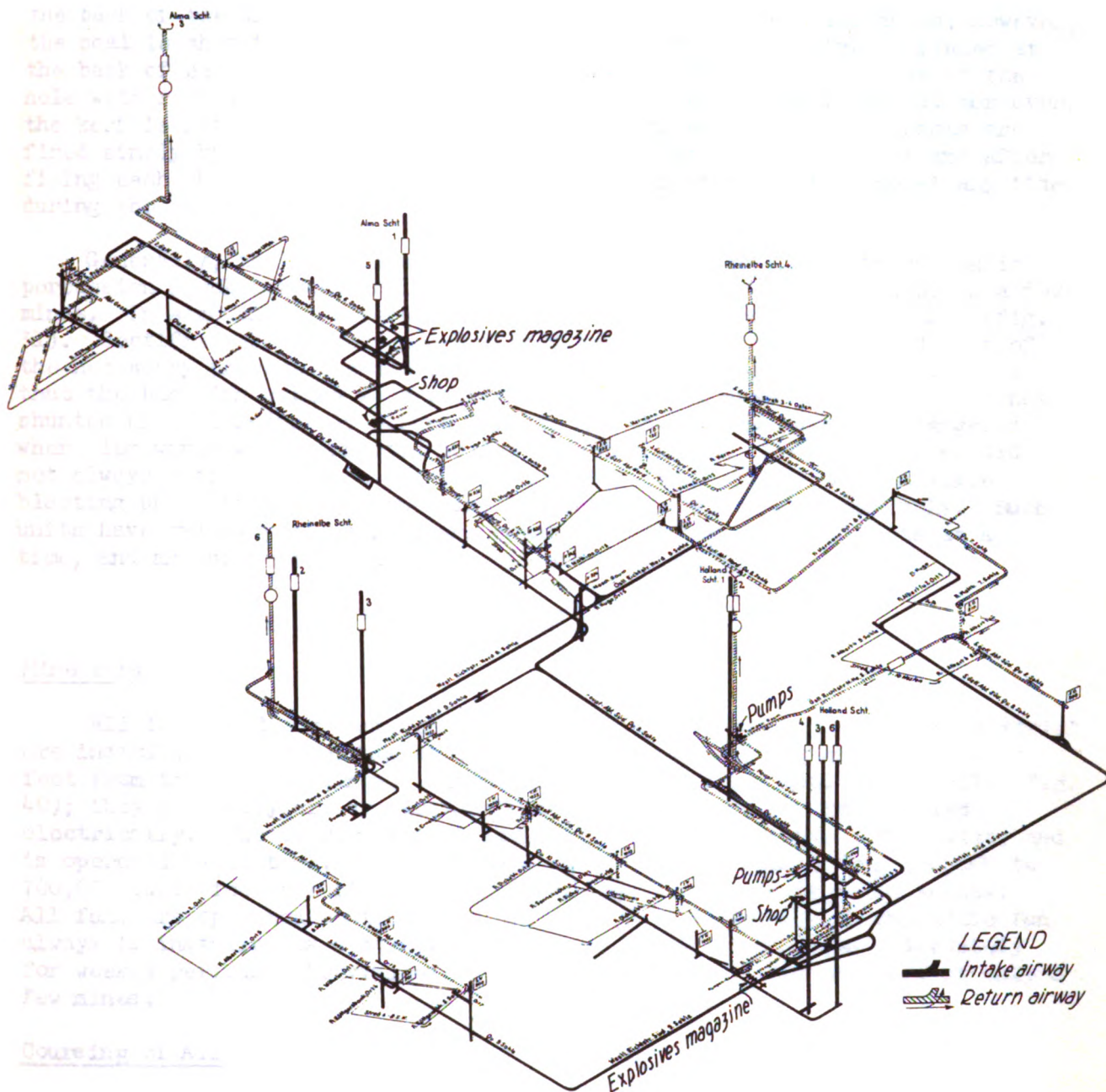


Figure 41. - Typical mine-ventilation map.

case and the permission to blast coal in one place does not apply to any other place, even if it is in the same mine or section of a mine.

Where the coal is undercut, boreholes are drilled to about 8 inches from the back of the undercut and about 12 feet apart. In many instances, however, the coal is shot from the solid. About 1/4 pound of explosive is placed at the back of each hole, and the charge is then stemmed to the collar of the hole with rock dust. Several holes are charged before one is fired; moreover, the kerf is not cleaned of cuttings before shots are fired. The shots are fired singly by an authorized shot firer, who tests for gas before and after firing each shot. When blasting of coal is permitted, it is done at any time during the shift.

Generally, the boreholes for blasting rock are drilled with pneumatic percussion (jack hammer) drills although rotary-type drills are used in a few mines. In some mines, several drills are mounted on movable carriages (fig. 31). Certified shot firers are employed for all such blasting, and most of the necessary precautions are observed. In many instances it was observed that the blasting cables were poorly insulated, detonator leg wires were not shunted until immediately before firing, and the joints were not staggered where leg wires were connected to the blasting cable. The shot firers did not always retreat to safe places before they fired shots. Magneto-type blasting units approved by the Mine Inspectorate are used exclusively. Such units have twist-type handles, are capable of firing up to 20 shots at a time, and are used in firing both coal and rock shots.

Ventilation and Mine Gases

Mine Fans

All fans used for inducing ventilation in coal mines in the Ruhr district are installed on the surface in fireproof housings and are offset 40 to 75 feet from the mine openings. Centrifugal mine fans are used exclusively (fig. 40); they generally are driven by steam engines, but a few are powered electrically. The average fan is about 28 feet in diameter, 4 feet wide, and is operated exhausting. Total volumes of return air ranged from 200,000 to 700,000 cubic feet per minute, with water-gage pressures up to 15 inches. All fans are operated continuously and attended constantly. A duplicate fan always is installed as a standby; usually each fan is operated alternately for weekly periods. Provisions to reverse the flow of air are made at only a few mines.

Coursing of Air

Generally, the intake air enters a mine through the main haulage shaft and is coursed to the lowest level. Separate splits of the main current are coursed along the haulageways of each active level, except the highest level, which serves as the main return airway (fig. 41). The mining regulations prohibit conducting the ventilating current downward except in intake air shafts, abandoned works, and workings that pitch less than 5 degrees. Development workings driven more than 5 degrees to the dip can be ventilated with air

currents conducted downward, provided permission is obtained from the Mine Inspectorate. The return air from development workings driven more than 5 degrees to the rise can be conducted downward, provided permission is obtained and the air flow therefrom is conducted directly to the main return. When more than one longwall face is worked from any level, each face is generally ventilated by a separate split of air. Air velocities along haulageways are limited by law to not more than 1,560 feet per minute; however, this is not applicable in shafts or main airways not regularly used as haulageways or manways. As entries were driven singly, air is conducted to the entry faces through metal tubing for distances up to 4,000 feet. These tubes are up to 60 inches in diameter and are equipped with compressed-air-driven booster fans inside the tubes at intervals not exceeding 600 feet. Rigid tubing was used exclusively.

Entries on the same level are driven singly and are connected with entries on other levels by blind shafts and by longwall faces extending from one level to another. As the backfill material in the mined-out areas forms walls that are usually not more than 25 feet from the face of the coal, the longwalls serve as crosscuts between intake and return airways.

Doors and Stoppings

Very few ventilation doors or stoppings are used; when used, the doors are self-closing and in multiple to form air locks, and stoppings are fire-proof. Many regulators are installed to control the air flow and almost invariably are on the return side of the air splits.

Liberation of Methane

Some methane is liberated in virtually every mine in the Ruhr district, and large amounts are liberated in some; several mines were liberating more than 1,000,000 cubic feet of methane in 24 hours. Consequently, the Mine Inspectorate considers every mine either gassy or potentially gassy and requires examination for methane in each working place within 3 hours before men, other than the examiner, are permitted to enter.

It is pertinent to mention that, ordinarily, the number of longwall places in a German coal mine does not exceed 25 and that many of them have less. The number of active working places in a very gassy mine is generally less than 20. Because of the great depths of air shafts and the extreme lengths of airways, the cost of ventilating any Ruhr mine is high, and where liberations of methane are unusually large, these costs are, of course, greatly increased. When the liberation of methane became so great as to require unusual methods of ventilation, a few of the operators attempted to adopt gas-saving methods that result in financial gain.

Gas-Saving Methods

One of these methods consists in advancing entries to their projected limits without otherwise extracting coal during development. After the entries are developed to their limits, 160-foot borcholes are drilled 60 feet

apart in the coal bed and other holes are drilled into the strata above and below the coal bed. Tight seals are erected near the mouth of the development entries to prevent the exuded methane from escaping into the mine air, and pipe connections are installed so that gas behind the seals can be pumped to the surface.

The first gas-suction plant in the Ruhr was installed at a mine at Langendreer and is reported to have operated at a profit for several years. The plant was installed when methane liberations began to endanger the safety of the mine and because of the economic necessity for reducing the hazard without increasing the cost of coal production. In this instance the experiment began with the sealing of mined-out areas and pumping out the gas liberated after pillar falls. The methane content of the atmosphere from the sealed area was reported to be 80 to 90 percent and amounted to almost 320,000 cubic feet of pure methane a day; moreover, the methane content of the general air in the working places was reduced from 2 to less than 1 percent. Later experiments in development entries and drilling of holes in adjacent strata have greatly reduced the quantity of methane liberations during subsequent mining operations, and the profits realized from the use and sale of the gas are reported to have exceeded the total cost of ventilating the mine.

Examinations for Gas

All certified miners are instructed in the use, care, and limitations of flame safety lamps, but only authorized officials are permitted to use them. Designated officials were expected to make on-shift examinations for methane, but this rule was not adhered to closely in some mines, possibly because methane was not being liberated in large quantities in those particular mines. Records of the examinations for gas were kept in books on the surface, and the signatures of top-ranking officials indicated that they studied the records every day.

Generally, the Ruhr mines are well-ventilated; however, small accumulations of methane were found in a few of the more than 100 mines visited. Such accumulations were found in places that were not swept by the ventilating current.

Mine Temperature

In parts of some of the mines the strata temperature was excessive. The temperature of the air in parts of the 2,600-foot level in one mine was 89.6° F.; water flowing from the strata at the rate of 40 gallons a minute had a temperature of 114.8° F., and temperature of the strata in 4-foot boreholes in the Carroll coal bed was 107.6° F. Mine-air temperature in parts of the 2,500-foot level in another mine was 100° F., and the temperature of strata in 6-foot boreholes in the Dickebank coal bed was 140° F. In such areas, men worked short shifts. The problem of reducing high temperature is causing some speculation on the part of far-seeing operators, because even higher temperatures are expected when the lower-level coal beds are exploited. Some form of refrigeration is being considered, but no definite action had been taken.

Coal Dust

Explosibility of Coal Dust

The volatile matter of the coal in the Ruhr district ranged from 7 to 45 percent; consequently, the coal dust in many of the beds is capable of propagating an explosion. An explosion at a Ruhr mine in 1947 took a huge toll of lives. The exact cause of the explosion was not made public, but there is little doubt that it was a coal-dust explosion initiated by a gas ignition.

Sources and Accumulations of Coal Dust

The principal sources of coal dust in the Ruhr mines are the crushing of coal by pressure of overlying strata (fig. 42) and the falling and sliding of coal in steeply inclined places. Other sources are the use of pneumatic picks for loosening coal, discharge of conveyors to mine cars or transferring coal to other conveyors, and the use of coal plows and scraper loaders.

Accumulations of coal dust were seen along virtually every longwall face, in return airways outby the longwalls, and along conveyor lines. Accumulations along return airways were heaviest and consisted of the finer particles. Accumulations of fine coal dust were seen, also, at many car-loading points. The dust in suspension at many of these loading points was so dense that visibility often was limited to a few inches. Generally, the mine cars were dust-tight; however, in some mines where repair parts for damaged cars were difficult to obtain, many cars had holes in their beds, which permitted fine coal and coal dust to sift through to the roadways. The cars were not overloaded.

Alloying Coal Dust

Ordinarily no effort was made to alloy coal dust at the working faces, but water sprays were installed at a few of the loading points; however, most of these sprays were ineffective, because the spray nozzles were either worn out or plugged with rust particles or fine coal. An experiment to alloy coal dust at its source was in progress in a mine near Gelsenkirchen where the coal bed is 50 inches thick, inclined about 25 degrees, and the coal is very dry, soft, and under great pressure. The space between the longwall face and the edge of the backfill material was about 15 feet wide. Mining with pneumatic picks two shifts a day, six days a week, advanced the face about 30 feet a week. The roof immediately above the coal bed is weak shale, and the floor is shale, which becomes very soft when wet. To alloy coal dust, the following steps were taken: Holes about 2 inches in diameter were drilled in the coal to a depth of 32 feet, 15 feet apart, about halfway between the roof and the floor. All holes were drilled on Sunday, when the mine was idle, the thought being that drilling would be necessary only once a week. Thus, water could be injected into the holes at any time during the shift by men assigned to that task. Twenty-nine gallons of water was forced into each hole at a pressure of 90 pounds per square inch, having the water pipe fitted with a device to seal the hole while the water was being pumped. The exact quantity of water was considered of utmost importance, because too much softened



**Figure 42. - Crushing of overburden is a source
of much fine coal dust.**

the floor and too little was ineffective. Twenty-nine gallons was determined as the best quantity in this instance but may not give satisfactory results in another, depending on the number and size of fissures evolved by pressure. Dust counts before and after the experiment were said to indicate a 60- to 70-percent reduction in number of dust particles. A few new employees in the area complained of the increased humidity caused by the use of water, but the older employees were enthusiastic about the system. Exact data on the humidity were not available.

A similar experiment was conducted in another mine near Kamen, where 1-1/4-inch holes 40 inches deep and 16 feet apart were drilled into the coal bed. Water was forced into each hole at 60 pounds per square inch pressure. Although dust counts had not been made at the time of the visit, the results were so satisfactory that the management planned to extend the practice to other faces.

Rock Dusting

Generalized rock dusting throughout the mines is not customary in the Ruhr district. There is ample evidence that some rock dust has been scattered along the haulageways by hand, and some of the entries in which "mother-belt" conveyors were installed were well rock-dusted. Mechanical rock dusting is unknown, and rock dust is not applied in working places, where flammable gas is most likely to accumulate.

In lieu of generalized rock dusting, rock-dust barriers are installed at intervals along the passageways. These consist of shelves (fig. 32) upon which rock dust is piled to its angle of repose; the shelves are installed over the roadways. Regulations required such barriers not more than 300 feet outby car-loading stations and in every entry near each intersection with another entry. Because of the comparative dryness of the mines and the low humidity of the air currents, the rock dust on the barriers was dry and readily dispersible. The mine officials and various German Government inspectors stated that they had definite knowledge of many instances in which the propagation of explosions had been stopped by such barriers.

Silicosis

It was reported that 3 to 12 men at each mine are released from work underground each month because of silicosis. Some of those men are not totally incapacitated and, upon the advice of physicians, a few are given employment on the surface.

There are several possible sources of silicosis in the Ruhr mines, but the most likely is dust from rock drilling and backfilling. Most of the rock drilling is done dry and, although most of the drillers are supplied with respirators, only a few wear them regularly while at work. The small cross-sectional area and the high velocity of the air current along some longwall faces also cause considerable dust to be thrown into suspension, which is especially dangerous when backfilling is done on shift.

As stated, many of the mined-out areas are backfilled with refuse from the preparation plant and crushed stone from rock headings. The material sometimes is blown by compressed air through pipe lines into the mined-out area or is dumped from cars in the upper gate road, from whence it flows by gravity into the mined-out area. The backfilling material travels several hundred feet through the compressed-air tubes or on the mine floor, and during this travel even wet washery refuse becomes very dry. The distance between the line of backfill material and face of a longwall is rarely more than 25 feet; thus, the dust evolved by additional backfilling is thrown into the ventilating current, and some of it is inhaled by miners working at the face. Undoubtedly much of the refuse contained siliceous material, because most of the men who contracted silicosis were employed near places where backfilling was done.

Transportation

All main haulage is by locomotives, intermediate and gathering haulage is by locomotives, conveyors, spiral chutes, ropes, and animals. Rope and animal haulage were observed in only a few places, and such systems are being abandoned as new workings are developed.

Haulageways

Main haulageways are driven in solid rock and, generally, on a uniform grade of 1 percent or less in favor of loaded trips. Curves are usually driven with a radius of at least 100 feet. The roadbeds are well-surfaced, well-drained, and reasonably clean.

Tracks and Switches

Track gages range from 18 to 28 inches. Rails weigh 30 to 70 pounds per yard and are heavy enough for the equipment in use. Wooden ties (in a few instances, steel ties) are spaced at suitable intervals and are usually set in ballast of good grade. Tie plates are used, and most of the rails are bolted (not spiked) to the ties; but the joints in parallel rails are opposite each other instead of being staggered, as is considered best practice in the United States. The reason given for this is that sections of the track may be constructed at central points and then transported intact to the places of installation. Multiple tracks along main roadways are common.

Track switches are similar to those in use in the United States. Guard-rails and lead rails usually are blocked to keep persons from catching their feet in them, and most of the switches are equipped with throws. Many of the main-line switch throws are operated remotely by compressed air, the control levers being suspended from the roof within easy reach of the locomotive operator. Only a few of the switch throws are of the parallel type, and many are installed so as to present a stumbling hazard.

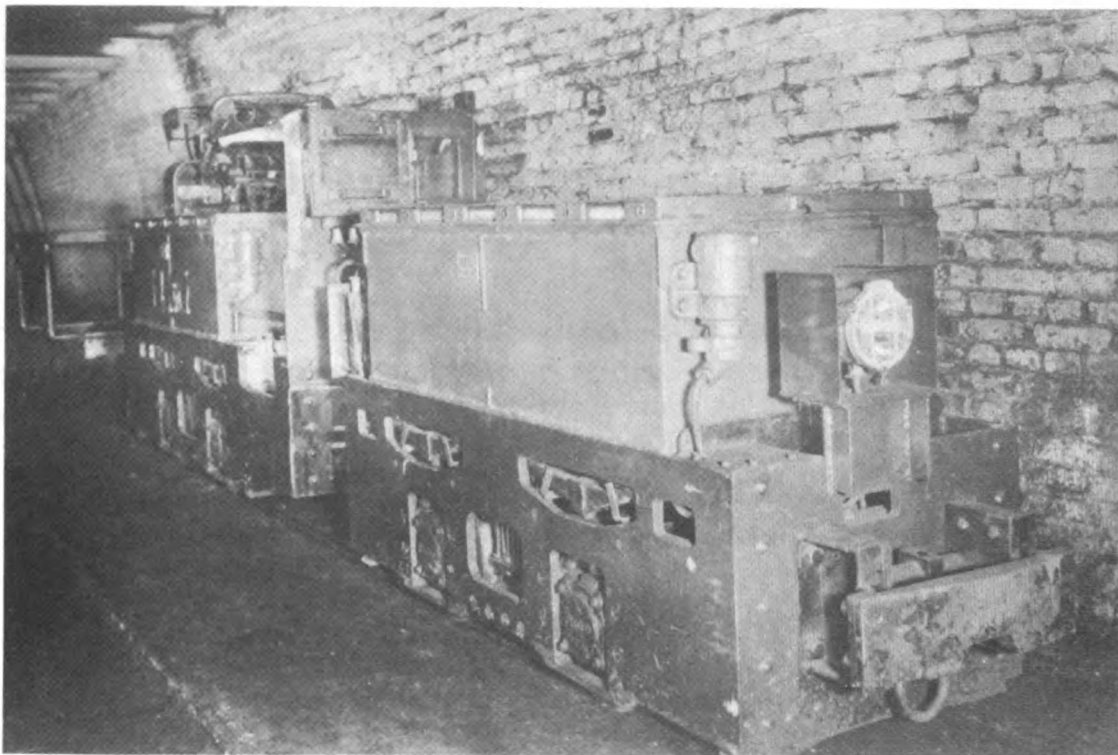


Figure 43. - Storage battery and combination battery-trolley locomotives.

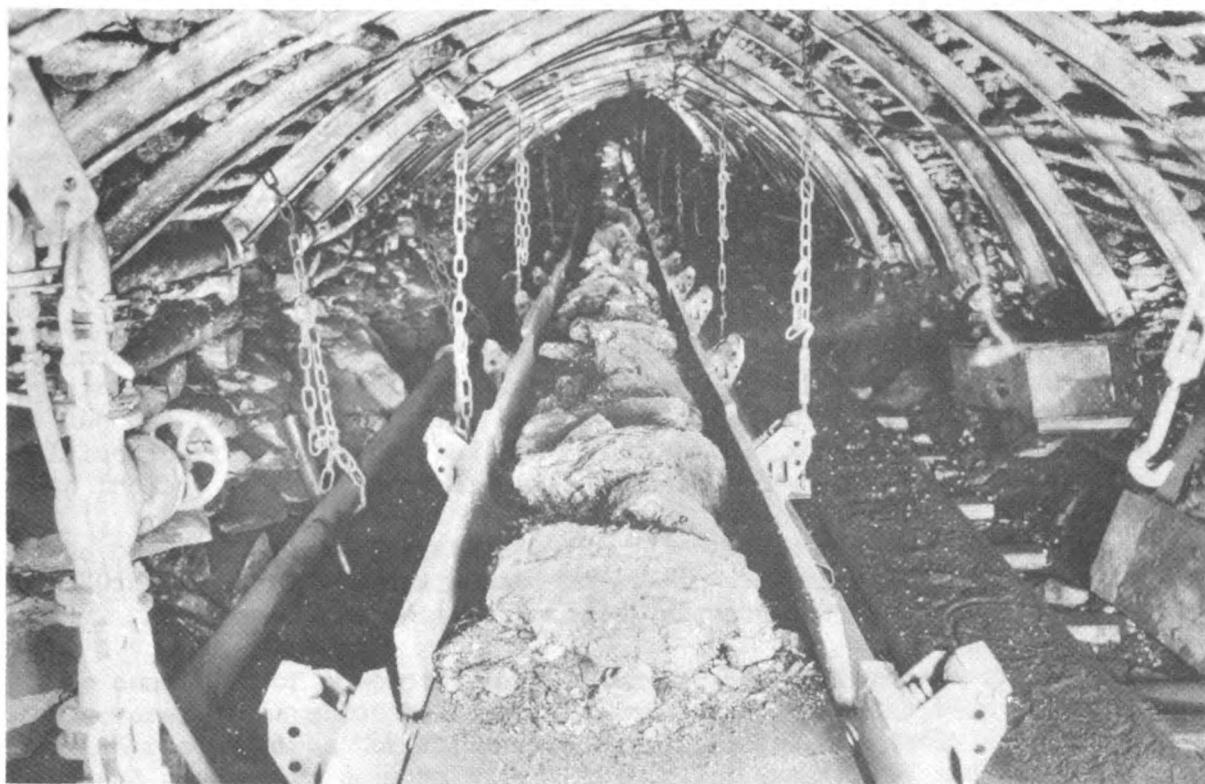


Figure 44. - Mother-belt conveyor suspended from roof.

Clearance and Shelter Holes

Ample clearance is provided along the main haulageways, but clearance in side entries and between the tracks at sidetracks frequently is not more than 6 inches. Safe crossings at places where men are required to cross conveyors are the exception rather than the rule. Shelter holes are seldom provided at switch throws and along the haulageways.

Locomotives

According to Dr. Fritzsche, Dean of Mining at the University of Aachen, approximately 2,500 locomotives of all types were in use in the Ruhr district in 1948. Of these, 1,250 were trolley type, 850 were operated by compressed air, 350 were Diesels, 50 were storage-battery type and a few were combination trolley and storage-battery types (fig. 43). Cable-reel locomotives were not used. All locomotives must be approved by the Mine Inspectorate before being put into service.

Dr. Fritzsche mentioned that trolley-type locomotives have been less expensive to operate and are more efficient. However, the mining regulations will permit their use only in intake airways where the methane content does not exceed 0.3 percent, the trolley wires must be at least 6 feet above the rails and 1 foot from the roof and the roof must be smooth. Trolley locomotives weigh up to 10 tons and are operated by 240 volts direct current.

Compressed-air locomotives are the most expensive to operate, according to Dr. Fritzsche, but they may be used anywhere that compressed air is available and are considered the safest. The number in use probably will not increase, he said. Small compressed-air-operated generators provide electricity for the operation of the headlights, which are of the vaporproof type. The air-storage tank consists of three to six high-pressure cylinders connected in parallel. Maximum pressure was 2,400 pounds per square inch, and each locomotive was equipped with a safety valve. The mining regulations require testing of cylinders at least once every 5 years.

The cost of operating Diesel locomotives is somewhere between that of the trolley and the compressed-air locomotives, continued Dr. Fritzsche. They cannot be overloaded, the exhaust gases may contain carbon monoxide, and their maintenance requires a large number of highly skilled mechanics. Their use may increase slightly, he said. One advantage claimed for the Diesel locomotive is that it can travel anywhere without a source of power such as trolley or compressed-air pipe lines.

The operating cost of storage-battery locomotives is about the same as that of Diesels, said Dr. Fritzsche, and their use probably will increase steadily. All Diesel and battery locomotives were the approved type.

The condition of locomotives was poor because of shortage of repair parts, and at several mines about half the locomotives on hand had been dismantled to provide repair parts for those remaining in service. Badly worn bearings, wheels, and gears were common; wiring insulation was frayed and saturated with oil; valves and pipe connections on Diesel and compressed-air locomotives

were leaky; and the exhaust fumes from most of the Diesels were obnoxious, if not actually dangerous. All main-haulage locomotives are built with covered cabs for the locomotive operators.

Conveyors

Mother-belt conveyors are installed in many mines, and many of them are suspended from steel arches that support the roof (fig. 44). Conveyors of all types were in very poor condition. The rubber belts were broken into short sections, and the sides were frayed and worn, until many belts were barely half their original width; shaker- and chain-flight conveyor pans were worn out; and new conveyor chains, flights, rollers, cradles, and disks were needed badly. Belt, shaker, and chain-flight conveyors were used only in flat and semi-steep workings, and chain-and-disk retarding conveyors were used in places that were either too steep or not steep enough for gravity flow.

Spiral Chutes

Spiral chutes are used in many of the blind shafts to lower coal from one level to another. These average 4 feet in diameter, and the maximum length is 750 feet. Frequently the spiral chutes are used as storage bins with capacities up to 250 tons. The spiral pitch ranges from 22 to 30 degrees. Ordinary steel spirals will transport about 150,000 tons of coal before they are worn out, but a manganese-steel spiral will transport about 1,000,000 tons, according to authorities.

Dispatching Systems

Most of the haulage operations are directed by dispatchers who transmit their instructions by telephone. Block-signal systems are installed in some mines. With but few exceptions, trips were handled carefully and kept under control at all times. The maximum speed of main-line locomotives is about 10 miles per hour.

Car-Spotting Hoists

A large number of car-spotting hoists are used; in fact, many are used for secondary haulage from side entries, especially at mines where the number of locomotives is limited. For instance, at one mine in Esson Frillendorf, 64 small hoists were being used to perform work that could have been done by four locomotives. Similar conditions existed to a lesser extent at several other mines. Virtually all car-spotting hoists were operated by compressed air and were in poor repair. They were not anchored securely; the drum flanges, gears, and pinions were badly worn; hoist ropes were broken and frayed; and, generally, the hoists obstructed the clearance. The rope on one hoist broke during an inspection of the mine and a man was killed by the runaway trip.

Mine Cars

The average number of cars at a mine in the Ruhr is high in comparison with the number in use at a comparable mine in the United States. The numbers range from 1,500 to 6,000, depending on the size of the mine; the average number is about 4,000.

All cars are of stool construction and are of the rotary-dump type. The beds are of 3-piece construction; that is, the sides and floor are in one piece molded to a U-shape, and the end pieces are welded onto the U-shaped pieces. They are watertight when new, and, except for the 3-ton capacity cars used at a few mines, the average car holds 1 ton of coal when level full. Cars are not equipped with brakes. Bumpers are essentially of thick steel plate fastened to the ends of the cars, and when the bumpers of two cars are together, the distance between the adjacent car beds is generally not more than 4 inches. Most of the couplings are the short link-and-hook type; both ends of each car are fitted with identical links and hooks, so that couplings can be made from either or both ends of a car. Many men are injured by having their heads crushed between cars during coupling. Some of the 3-ton capacity cars, however, are equipped with automatic couplings. Mine-car wheels are about 12 inches in diameter with treads 3-1/2 inches wide and are assembled to an 18-inch wheel base. Virtually all car wheels are fitted with either cylindrical or tapered roller bearings, but some have ball bearings. Special cars are used for transporting timbers and supplies.

Many of the mine cars were in poor condition because of age and lack of replacement parts. Wheels and bearings were worn, and many of the car bodies had large holes through which coal sifted onto the roadways. At some mines, at least half of the cars were out of service in need of repair.

Safety Measures

The use of derails, stopblocks, or safety chains is not customary in Ruhr mines; instead, standing cars and trips usually are secured with sprags or are "scotched" with chips of wood. Rerailers or lifting jacks are not carried on locomotives, but in most mines retracking devices are built in the roadways near main-line switches at about 1,000-foot intervals. The use of trip lights on the rear of trips is required by the mining regulations, and the rule was observed when trip lamps were available, which was not often. Only authorized persons are permitted to operate locomotives, and this rule seemed to be followed strictly. Generally, brakemen or trip riders are not employed; consequently, locomotive operators are required to throw all unattended switches and to couple all cars not already coupled at the loading points and sidetracks. It is not unusual to see a motorman get off a moving locomotive and run ahead to throw a switch.

Man-trips

Man-trips are not operated as a general practice, and men are required to walk to their working places; however, when man-trips are operated, the men ride in ordinary mine cars. Electric power is disconnected from the trolley wire when men board and alight from man-trips. Man-trips are under the supervision of officials who ride in them and the trips are operated in a safe manner. Men frequently ride on all types of conveyors, but special safety precautions are not observed. When travelling across longwall faces, it is sometimes necessary to ride on the conveyors because of lack of clearance. Several men were injured, four of them fatally, when a chain-and-disk conveyor upon which they were riding down a steep place broke and ran away.

Electrical Installations

Very little electric power is used underground in the Ruhr district. All underground electric equipment except trolley locomotives, motor-generator sets, and a few of the blind-shaft hoist motors is of the approved type; virtually all is operated by 240 volts direct current.

All electric machines and devices, including the armoring of cables, were frame-grounded.

Substations

Substations are brick or concrete-lined rooms excavated in solid rock. The equipment is well-installed, and doors to the substations are kept locked unless an authorized person is present. Danger signs to warn persons of high voltage are posted at appropriate places, but insulating mats usually are not placed on the floor in front of switchboards. Oil-filled transformers, the only kind used in substations, generally are isolated by screens or fences.

Power Lines

Power lines from the main power plant enter the mine through the intake shaft and extend through an intake airway to the main substations near the bottom of the shaft. The power lines were well-insulated and well-installed. Power cables along entries usually are supported on steel brackets attached to the roof supports. The cables are well-insulated and are fastened to the brackets by means of metal hooks (fig. 32). Trolley wires are suspended above the center of the tracks 6 feet above the top of the rails; their alignment was good and none were in contact with the roof, ribs, or timbers. Connections between trolley and feeder lines are required at intervals not exceeding 3,000 feet and cut-out switches are installed at each junction. The wires are anchored securely and insulated properly at the ends, but they are not guarded at places where men are required to pass beneath them. Trolley wires are not permitted within 325 feet of car-loading points or working faces.

Bonding

When trolley-type locomotives are used, the rail joints are either bonded or welded; however, only one rail is bonded, and cross bonds ordinarily are not used.

Pumps

Only a few electrically operated pumps are used in Ruhr mines, and most of these are installed in well-ventilated, fireproof rooms near the main shaft. Portable and gathering pumps are operated by compressed air and are installed safely.

Battery-Charging Stations

The underground storage battery-charging stations are in fireproof rooms ventilated by air that returns directly to the surface. Fire doors usually isolate these stations from other parts of the mine, and at least one attendant is on duty constantly at each station.

Telephones

Telephones generally are installed at each shaft landing (including the landings at blind shafts), at the junction of main passageways, and at other important points in the mines. The underground systems also are connected with telephones on the surface. All the underground telephones are of a type approved by the Mine Inspectorate. Telephone wires are insulated and installed on the side of entries opposite the power wires.

Underground Lighting

Generally, the area near main underground shaft landings is well illuminated, but not at many blind-shaft landings. Frequently, the only illumination at these sometimes busy landings is provided by a workman's lamp hanging from a roof support. A few haulageways are illuminated for short distances by electric lights in vaporproof enclosures, but this is uncommon because of the scarcity of bulbs. Where electric lights, except signal lights, are installed in working places, each light receives its power from either a separate, small, compressed-air-operated generator mounted in its base or from a compressed-air-operated, portable, approved-type generator in the intake airway. This system is approved by the Mine Inspectorate.

Guarding of Machinery

Large repair shops were common, both on the surface and underground. In most of these shops an attempt had been made to guard the moving parts effectively, but a few belts, pulleys, gears, and pinions were not guarded, and some of the shops were poorly lighted. Poor illumination in surface shops in most instances was due to the fact that the shops were in temporary structures, the original shops having been destroyed during the war.

All working places except those inclined more than about 42 degrees from the horizontal contain chutes or conveyors of various kinds; some of them contain a combination of two or more kinds. These conveyors are seldom more than 300 feet long and are operated by compressed-air motors or approved-type electric motors, and in most instances booster or auxiliary motors are installed at intervals along separate conveyor lines. Virtually none of this equipment was guarded adequately. Most of the motors that drive belt and chain-flight conveyors along entries are operated by compressed air, but a few are operated electrically. The electric wiring was poorly insulated and was not installed on insulators.

Hand Tools

Hand tools for miners were usually poor in both quantity and quality. The metal in axes, saws, and percussive-pick bits could not be tempered properly, and many of these implements were too dull to work efficiently. The normal complement of face workers' tools generally consisted of a percussive pick, shovel, a hatchet and saw where wood was used for timbering, or a small sledge hammer where steel timbering was done.

Underground Fire Prevention and Control

The mine regulations require an outline to be posted at each mine of the procedure to be followed in the event of a mine fire. Fire-fighting procedures have been discussed and adopted by the officials of each mine, some of whom are available on the surface 24 hours a day. Organized fire-fighting crews, consisting of specially trained workmen, are available on each shift. Mining regulations also require that devices for sealing the mine opening quickly be provided near the collar of each intake air shaft and that emergency fire doors be installed near each shaft landing of an intake air shaft. Fireproof zones were prepared in the roadways leading from the intake air shafts of most of the mines. These consist of an area about 100 feet long where the roof and ribs are supported entirely by masonry and combustible material is not present. Fire extinguishers, rock dust, and sand, bricks, and cement for building seals are available at most of the important underground places, and water lines are extended in a few places. Compressed-air lines extend into virtually all active sections in every coal mine, and provisions are made on the surface to use these lines as water lines in case of necessity.

Miscellaneous

Mine Maps

Up-to-date mine maps almost invariably are available at every mine. Separate maps indicate the workings in each coal bed (fig. 41), and an isometric drawing in colors portrays the ventilation and haulage systems and the locations of power lines, compressed-air lines, substations, and other vital installations. Every mine in the Ruhr has a standard color scheme to indicate the various levels and installations on the isometric drawings. Copies of these maps, however, are not posted for examination by the mine employees.

Protective Pillars

The mining law requires barrier pillars 65 feet thick along the boundary lines and adjacent to abandoned workings. These barrier pillars can be penetrated or removed only by special permission of the Mine Inspectorate. In order to regulate surface subsidence, or for other reasons, certain sections of mines are sometimes abandoned temporarily and permitted to fill with water. At one mine where this was done, an exact survey either was not made to locate the limits of the area before it was abandoned, or officials of an adjacent mine were not warned; at any rate, in 1948 the workings of one mine cut into water-filled workings of another, and 11 miners were drowned.

Escapeways

Each coal bed and each level has at least two connections with both outlets to the surface. They were in safe condition for travel and reasonably free of obstructions when inspected, but direction signs were not posted in them at all necessary places. Each shaft is equipped with either a cage or a travelable stairway, and the stairways were said to be inspected at least twice a year.

Miners' Lamps

Underground employees use acid-filled battery lamps that are carried in the hands. When a workman reaches his working place, he either hangs his lamp on a roof support or places it on the floor nearby; however, the illumination afforded by the lamp is inadequate, and the shadows of other objects sometimes cause accidents. Many of the lamps are at least 20 years old, and, because of the shortage of lamps and repair parts, the efficiency of the men in many mines was reduced. The mining law requires that the number of lamps provided be 5 percent greater than the number of underground employees, but at several mines visited there were fewer lamps than underground workmen, many of whom attempted to work by double-shifting lamps that were not fully charged.

Check-in and Check-out System

Each lamp is numbered, and each person who goes underground is required to present an identification check before he can obtain a lamp. These checks are kept in the lamp house until the person returns to the surface. Thus, an accurate record of the men in the mine is kept; however, miners do not carry positive means of identification on their persons.

Protective Clothing

About 95 percent of the underground employees wore protective caps of thick leather, but virtually none wore safety shoes, because such shoes were not available. As a matter of fact, work clothes of all kinds were scarce, and many workmen on duty underground were naked except for shoes and caps. Knee pads for workmen in thin coal beds and buttock leathers for men in steep places also were scarce. A buttock leather (asch leder), incidentally, is similar to a blacksmith's apron without a bib and is worn by men who perform most of their work from a sitting position.

Smoking

Smoking in any German coal mine is forbidden, and the underground employees are searched at frequent but irregular periods for smokers' articles and lighting devices. Evidence of smoking was not observed in any of the mines visited.

Housekeeping

Generally, the housekeeping underground was excellent along the main passageways. Underground structures were free of paper and other waste materials. Mine supplies were stored so that they would not fall or obstruct

the walkways, which were reasonably free of mud and debris. On the other hand, travel through many of the working places, particularly the flat ones, was difficult and in some instances dangerous. Extra conveyor pans, posts, and loose coal and slate were piled on the mine floor in the restricted traveling space, and the overhead compressed-air lines and hose for the pneumatic picks were suspended carelessly from the roof. Toilet facilities were provided for every active working face along main travelways and near underground shops and shaft landings.

GENERAL SAFETY CONDITIONS

Mine Inspectorate

The Mine Inspectorate consists of a chief of the department, three assistants who serve as division chiefs, 21 district inspectors, and the necessary office personnel. The chief, his assistants, and the district inspectors are technically trained men who have served special apprenticeships to fit them for their positions. These men are invested with considerable authority and, in addition to their authority over matters pertaining to safety, they also control the methods of mining, planning, timbering, ventilation, dust control, drainage, transportation, and the types and kinds of equipment used. Decisions of inspectors in matters pertaining to safety, production, and equipment have the effect of law; however, the decision of an inspector can be appealed to the Chief of the Mine Inspectorate, whose decision is final. The inspectors known to the authors were well-qualified as to experience and training and commanded the respect of both management and labor. A division chief or one of the district inspectors accompanied each of the authors on most of the underground inspections.

As a rule, the German mine inspectors do not devote the attention to minor hazards that a company, State, or Federal inspector does in the United States. The German inspector is interested primarily in disaster hazards and is an expert in recognizing them; however, when a serious hazard is observed, he does not hesitate to stop all work until the hazard is removed. The district inspector has the authority, and occasionally exercises it, to recommend the demotion or removal of an underground official for failure to comply with the mining regulations.

Supervision

The management and top officials invariably are technically trained men and well-qualified by training and experience. Most of the higher officials possess master's and doctor's degrees in engineering. Special preparation and training are required of the engineers charged with the responsibility for preparing the mining plans, surveys, and maps. Each engineer and official is required to serve an apprenticeship before assuming a position of responsibility. Each mine official and each employee operating mechanical equipment is required to have a certificate of competency. Officials are certified directly by the Mine Inspectorate, but other workmen may be recommended for certification by local mine officials, uncertified men are permitted to work only as apprentices or assistants to certified men. Each person employed underground is required

to serve an apprenticeship of 2 to 4 years before being certified as an experienced miner.

The number of men supervised by each foreman is not uniform. A foreman in charge of a rock heading may supervise the work of only 8 or 10 men, whereas the foreman in charge of a long face may supervise 200 men. On long faces, however, the foreman usually selects some of the more capable workmen to act as overseers of less experienced men. Discipline at several mines was poor because it was alleged that the supervisors feared being charged with having been members of the Nazi party. If such a charge could be proved, the coal company was required to discharge the accused person, who in all probability then would be prosecuted by the occupation authorities. Generally, however, the relationship between management and labor was good.

In addition to the preshift examinations by fire bosses, the working places are visited at least once each shift by other officials. Although these officials have ample time to inspect the places carefully, the examinations frequently are made in a perfunctory manner; the roof is not examined carefully, and tests for gas are seldom made. Initials and date marks are made only by fire bosses, who write these on boards installed for this purpose and spaced at irregular intervals along the faces. Permanent records of inspection are kept on the surface.

Safety Organization and Promotion

Each large company and many of the smaller ones employ safety engineers. They are given full authority to take any action necessary to correct a hazard, and most of them take immediate action when a hazard is observed.

Committees of miners whose sole purpose is the furtherance of safety are not general in the Ruhr district. However, any hazard seen by a workman may be considered a grievance to be handled by the grievance committee. This committee does not make periodic safety inspections of the mine.

Joint safety meetings of workmen and officials are not held, but safety problems are discussed during meetings of officials and members of the grievance committees. Safety bulletins and pictures are posted at conspicuous places in the enclosure at some mines. Special safety rules are adopted at only a few mines; the mining laws are used as a guide by most officials and men. New men are required to work with experienced men until they become familiar with the laws and with the hazards incident to their particular occupations.

Accident Statistics

All accidents involving injury to workmen are reported, regardless of whether the victims lose time from work; however, a lost-time accident is one in which the victim is absent from work for more than 3 days. An accident is classified as serious when the victim is incapacitated more than 8 weeks, and all fatal and serious accidents are investigated by officials of the Mine Inspectorate.

Desultory campaigns to reduce the number of accidents had been made by individual companies, but concerted efforts were not begun until 1924. The results of these efforts became apparent immediately, and the trend in the frequency of accidents of all kinds was downward until 1937. About that time, war clouds began to gather over Europe and the number of mine accidents increased steadily until the last stages of World War II. During the period immediately following the war there was no organized effort to prevent accidents to mine workmen. Furthermore, because of the shortage of experienced miners, many untrained men were employed in the mines; because of the food shortage and the lack of stabilized currency, the miners were undernourished. Owing to the fear of being accused of being former Nazis, the underground officials made little effort to maintain discipline; consequently the number of accidents soared to unprecedented heights. The data in tables 1, 2, and 3, and figure 45 were furnished by officials of coal companies and the Mine Inspectorate. The more detailed records were destroyed during the war. These data include accident records at one mine during 1947 and at two mines during the first 6 months of 1948 but are not necessarily typical of all mines in the Ruhr district. It should be emphasized that food was scarce during this period, and most of the miners were undernourished.

TABLE 1

Mine No. 1

Month	Shifts worked during first 6 months of 1946			Accidents involving loss of 1 week or more			Per 10,000 Shifts
	Underground	Surface	Total	Underground	Surface	Total	
Jan.	15,764	7,803	23,567	40	6	46	19.09
Feb.	15,540	7,346	22,886	30	5	35	15.29
Mar.	16,352	7,863	24,215	58	9	67	27.67
Apr.	16,127	8,560	24,687	52	2	54	21.87
May.....	14,394	7,540	21,943	40	6	46	20.86
June.....	17,261	8,867	25,940	34	6	40	15.42
Total.....	95,438	47,800	143,238	254	34	288	20.11

Mine No. 2¹

Jan.	18,002	14,453	32,455	40	4	44	13.59
Feb.	17,776	13,700	31,476	21	3	24	7.62
Mar.	19,063	14,169	33,232	27	7	34	10.49
Apr.	17,264	15,060	32,324	40	5	45	13.93
May.....	16,051	13,246	29,297	36	6	42	14.34
June.....	19,402	14,896	34,298	36	9	45	13.12
Total.....	107,558	85,524	193,082	200	34	234	12.12

1/ Includes large cokery and byproduct plant.

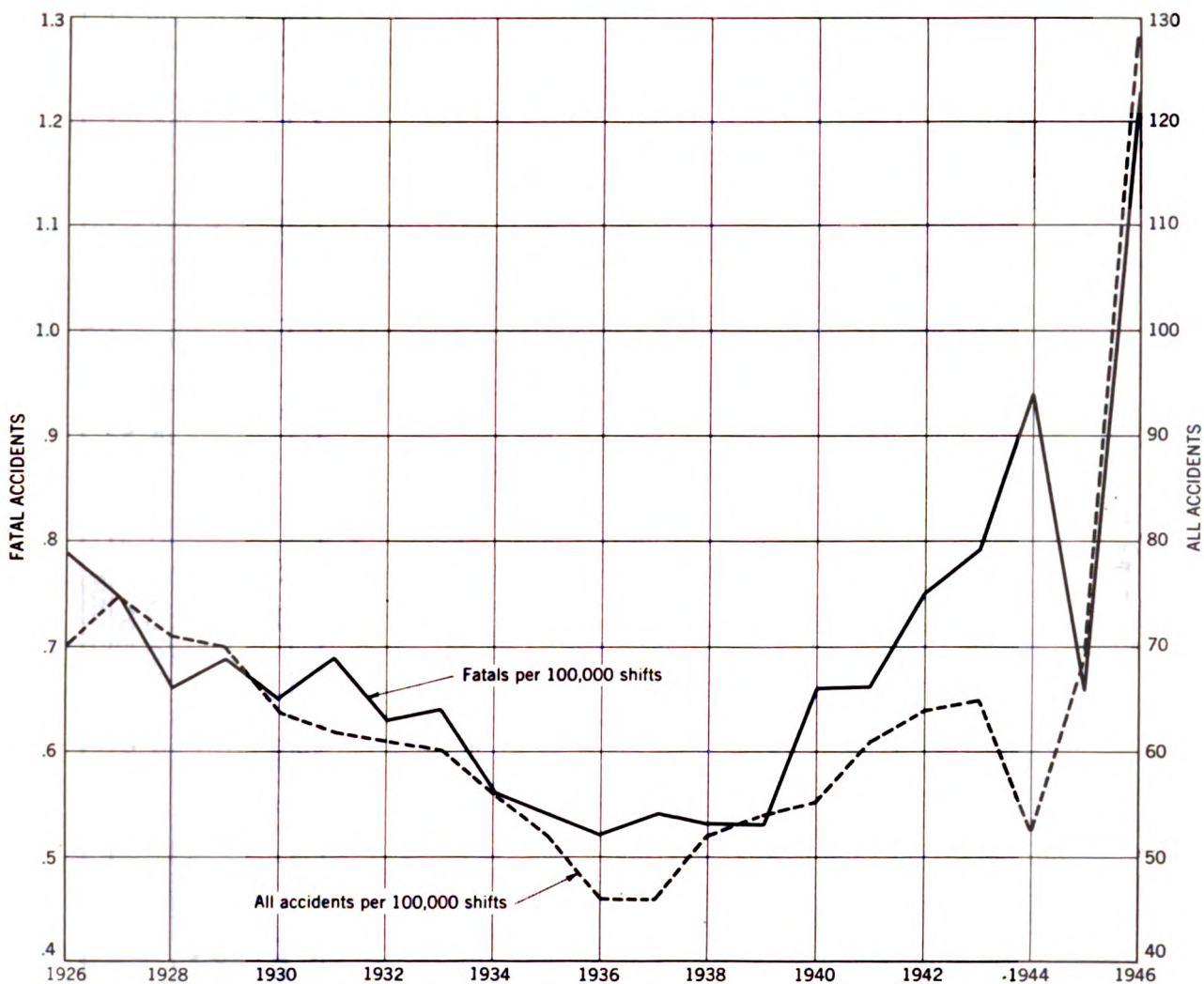


Figure 45. - Mine-accident trends, 1926-1946. This chart indicates graphically the trend of accidents in and about all mines in the Ruhr district of western Germany. Beginning with the campaign to reduce accidents in 1924, the trends were downward until 1937, when the clouds of World War II began to collect over Europe.

TABLE 2. - Accident record at Mine 3 during 1947

	Underground		Surface		Total	
	No. of accidents	No. per 100,000 Shifts	No. of accidents	No. per 100,000 Shifts	No. of accidents	No. per 100,000 Shifts
Fatal accidents.....	13	1.0	-	-	13	1.0
Serious accidents (more than 8 weeks)...	23	1.9	3	0.2	26	2.1
Lost-time accidents (4 to 8 weeks).....	97	7.8	5	0.4	102	8.2
Minor accidents (3 days to 4 weeks).....	3,046	242.0	247	19.6	3,293	261.6
Total.....	3,179	252.7	255	20.2	3,434	272.9

No. of employees 1947:

Underground..... 3,566
Surface..... 1,157
Cokery..... 219
Office and officials. 316
Total..... 5,258

Total production 1947...1,390,096

TABLE 3. - Accident record of mines in the Recklinghausen No. 1 Inspection District during 1947

[All accidents are reported regardless of whether lost time is involved]

Mine	Type of accident	Underground	Surface	Total	Per 100,000 Shifts	Production 1946	Production 1947
Emscher-Lippe.....	Fatal	2	-	2	0.231		
	More than 3 weeks	67	12	79	9.114	447,604	672,302
	All accidents	654	142	796	91.837		
Ewald 1/2.....	Fatal	4	1	5	0.731		
	More than 8 weeks	42	8	50	7.312	475,114	526,974
	All accidents	860	88	948	138.631		
Ewald 3/4.....	Fatal	2	-	2	0.390		
	More than 8 weeks	43	3	46	8.978	400,062	469,332
	All accidents	504	47	551	107.545		
Ewald Fortsetzung.....	Fatal	5	2	7	0.718		
	More than 8 weeks	66	8	74	7.590	607,362	753,224
	All accidents	626	107	733	75.182		
Konig-Ludwig 1/2.....	Fatal	2	1	3	0.396		
	More than 8 weeks	62	15	77	10.171	408,999	515,135
	All accidents	726	131	857	113.206		
Konig-Ludwig 4/5.....	Fatal	2	1	3	0.365		
	More than 8 weeks	51	16	67	8.150	555,589	599,311
	All accidents	841	154	995	121.031		
Julia.....	Fatal	1	-	1	0.206		
	More than 8 weeks	28	4	32	6.597	373,658	381,831
	All accidents	493	46	539	111.110		
Recklinghausen No. 2....	Fatal	2	-	2	0.342		
	More than 8 weeks	73	6	79	13.516	421,305	529,201
	All accidents	760	42	802	137.215		
Central Cleaning Plants.	Fatal	-	1	1	1.956		
	More than 8 weeks	-	2	2	3.913		
	All accidents	-	16	16	31.301		
Total.....	Fatal	20	6	26	0.453		
	More than 8 weeks	432	74	506	8.818	3,649,693	4,447,910
	All accidents	5,464	773	6,237	108.701		

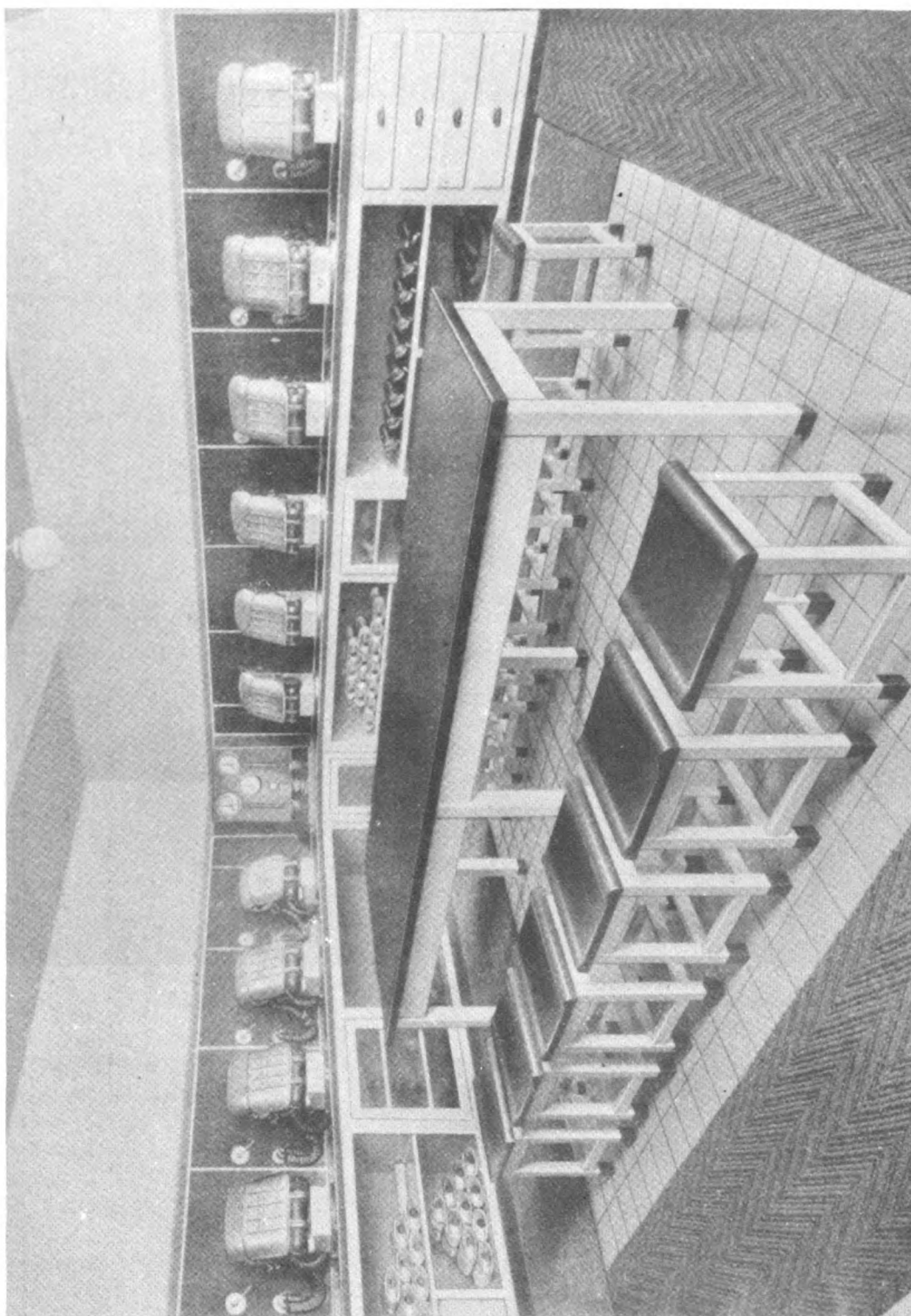


Figure 46. - Well-maintained mine rescue station.

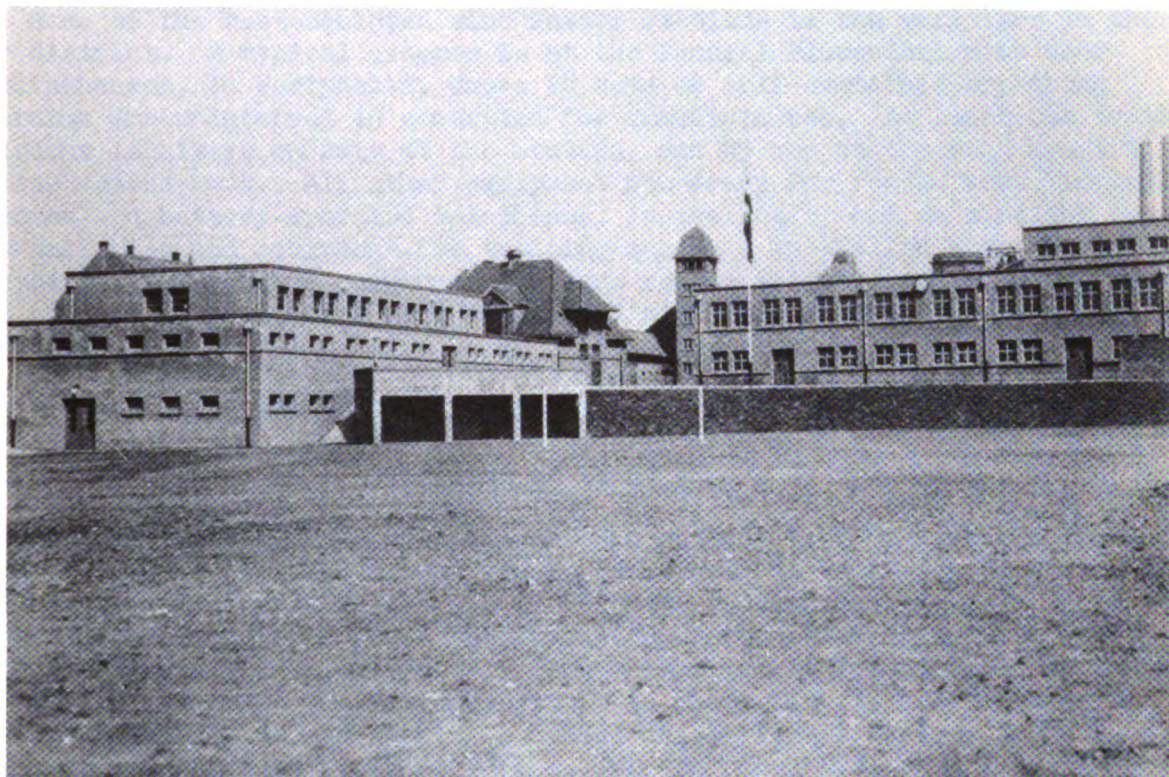


Figure 47. - Training shop for apprentice miners.

First Aid and Mine Rescue

Many of the miners and all officials are trained in first aid, and surface first-aid stations are maintained at virtually every mine. Many of them are staffed with doctors and nurses, and others are staffed with well-trained attendants 24 hours a day. At some mines, very little first-aid equipment, except stretchers, is stored underground; it is kept in a first-aid room on the surface. Most of the first-aid station attendants are so well trained that they are capable of treating all injuries, except those requiring surgery or special prescriptions. Virtually every coal company maintains an ambulance in connection with its surface first-aid station.

Some of the best-equipped mine rescue stations in the world are in the Ruhr district. A typical example is at the General Blumenthal mine near Recklinghausen, in Westphalia, where 26 sets of self-contained breathing apparatus are maintained in condition for immediate use. At least one trained attendant is always on duty at the station, and 45 men at the mine are trained in mine rescue work. All other equipment necessary for rescue work, including pulmotor and battery-operated telephones, is available; and an airtight room with galleries and equipment for training men in a gas-filled atmosphere is maintained. Many other company-owned mine rescue stations in the Ruhr district were equally up-to-date; a well-maintained mine rescue station is shown in figure 46.

EDUCATION AND CONDITIONS OF EMPLOYMENT

Training of Young Miners

Most of the coal companies support and conduct training schools for young miners. Boys who wish to become miners can enroll in these schools at the age of 14 years. They work in special shops (fig. 47) and as helpers at every surface occupation for 2 years and combine such manual training with about half-time training in class rooms. Upon completion of training on the surface, the boys are employed underground, either in groups in specially prepared sections or singly as assistants to selected experienced workmen for 2 years more. The underground training period also includes part-time classroom work. The boys work at every occupation until they become familiar with it and the hazards incident thereto. Upon completion of surface and underground training, the boys are required to take examinations, and if successful they are given certificates of proficiency as apprentice miners, after which they are required to work underground as apprentices for at least 1 year before being granted certificates as full-fledged miners. Those who complete the training-school courses before obtaining miners' certificates receive about 5 percent more pay than others performing the same kind of work. The boys in training are paid a nominal sum for their efforts and enjoy many of the privileges of miners. For example, they are members of the trade union, are given the special ration points that are issued only to miners, and are entitled to the hot meals given only to persons connected with the coal-mining industry. Some coal companies had as many as 400 boys in various stages of training, and statistics proved that minors who completed this training were more efficient and less likely to suffer injuries while at work.

Status of a Coal Miner in Germany

Generally, a coal miner is looked up to throughout western Germany. His rate of pay is higher than that of the average workman in other industries, and he is given privileges not enjoyed by other workmen. For instance, he was allowed ration points for 1,500 calories of food when other Germans were allowed only 900 calories, and he was given ration points for other articles that were sold only to coal miners. His rate of pay was about \$4 a day when other laborers could earn only about \$3. Prior to 1890, a coal miner was considered such an extraordinary person that he was permitted to bear arms, a privilege not accorded other citizens. During the first and second World Wars, the skill, versatility, and initiative of coal miners were recognized and so highly regarded by the military authorities that serious manpower shortages developed in the coal mines.

Except for the foregoing factors, the miner's status is probably the result of his own attitude. He knows that his work demands skill and initiative, he knows that the products of his skill are vital to the economy of his country, and he never overlooks an opportunity to impart this knowledge to others. Moreover, the leaders in the coal-mining industry - the mine operators, mining engineers, and teachers in coal-mining schools - are constantly extolling the advantages of being a coal miner in order to attract young men to the profession.

Employment of Aged or Disabled Miners

A common practice of coal companies in the Ruhr district is to establish workshops for employees who, because of old age or physical disability, are no longer able to do hard work. Such men are trained to make toys, repair leather shoes, make wooden shoes, and paint small objects. The workshops are well-equipped and well-maintained; the workmen receive the same pay that able-bodied men doing comparable work receive, and they enjoy all the privileges of full-time miners. At one of the mines visited, twelve of these men were engaged in making Easter toys for children, and they had made enough to fill three large storerooms. Each man seemed to be proud of his skill, and none appeared conscious of his physical handicap. A few companies, however, employed disabled or aged men about the various surface operations, with the result that after several years all the surface positions were filled by such employees and the work was not done efficiently.

Insurance and Hospitalization

Each miner and each member of his family is entitled to medical and hospital services, for which a nominal sum is deducted monthly from the pay of the employee. The choice of a doctor or hospital, however, rests with the individual. Another deduction from his pay is for social insurance, including payments for a pension or retirement allowance after he is no longer able to work.

Virtually every mine is near a hospital. Many of the hospitals were damaged severely during the war, and most of them were overcrowded when visited by the authors; however, seriously injured persons usually are given prompt

and effective attention. A hospital was established by the owners of the Emscher-Lippe mine near Datteln for children of miners up to the age of 12 years, and about 60 children were patients when the hospital was visited. The hospital was nonsectarian, operated on a nonprofit basis, and more than 1,000 children were treated during the 2 years prior to the visit. It was clean, airy, and well-arranged but almost entirely lacking in medical supplies. The hospital staff consisted of 2 physicians, 14 nurses, and 8 nurses' aides.

EFFICIENCY AND COST OF PRODUCTION

Efficiency of German Mining System

Sometimes statistical comparisons are made of the relative efficiency of American and German coal miners and the respective coal-mining industries, generally to the disparagement of the Germans. The basic comparison relates to the average daily output per underground workman; obviously, when such statistics alone are considered, the record in the United States is outstanding. However, the great difference in average mining conditions and the necessity in Germany for regulating surface subsidence should be considered when comparisons are made:

The average depth of shafts in Germany is at least four times that in America; nearly half the total production in Germany is from coal beds that are inclined more than 25 degrees, and at least one-fourth is from inclinations greater than 35 degrees. Many German coal mines are operated under cities, rivers, railroads, and highways, where subsidence must be regulated strictly in order to prevent excessive damage to surface installations. The mining laws prohibit the use of explosives and electric equipment in most face regions; therefore, compressed-air equipment is in general use.

In view of the foregoing, it is not surprising that the number of non-productive workmen ("company men") in a German coal mine is much higher than the number in a comparable American mine.

Cost of Production

Table 4 shows the breakdown of 1947 costs at a mine that produced a total of 469,332 tons of coal during that year. The costs were obtained during a period when the ceiling price of coal was \$8.33 per ton, indicating a loss of \$1 per ton. The costs at this mine were probably typical, but it should be remembered that they were obtained during a period of extreme unrest. Experienced miners were scarce, the rate of absenteeism was high, men were undernourished, and virtually all the equipment was in need of repair. Furthermore, the actual value of the Reichsmark was extremely uncertain, so that the percentages of total expenditures probably will provide the more accurate basis for comparative purposes.

TABLE 4. - Costs at a Typical Mine During 1947

	Costs per ton	Percentage of total cost
A		
Labor underground.....	\$2.61	28.67
Labor on surface.....	.24	2.66
Salaries.....	.26	2.82
Legal and social expenses.....	.65	7.19
	3.76	41.34
B		
Power costs.....	.80	8.74
Pit wood.....	.22	2.40
Supporting materials, steel.....	.06	.64
Other supporting materials, bricks, etc.	.04	.44
Explosives, detonators, etc.	.01	.15
Other stores materials.....	.34	3.79
Supplies and services by other company-owned plants.....	.52	5.76
Supplies and services by others.....	.30	3.26
Reconstruction.....	.07	.75
	2.36	25.93
Revenues.....	.01	.10
Total supplies.....	2.35	25.83
C		
Surface damages.....	.18	1.96
General costs closely connected with operating.....	.41	4.50
	.59	6.46
D		
Operating costs (A + B + C).....	6.70	73.63
E		
Insurance, compensation, and taxes.....	.18	1.93
Administration.....	.10	1.15
	.28	3.08
F		
Operating costs (D + E).....	6.98	76.71
G		
Cost of labor turn-over.....	.09	.99
H		
Depreciation.....	.64	4.49
Capital service charges.....	1.05	11.51
	1.69	16.00
I		
Auxiliary power plants.....	.16	1.76
Tenements.....	.16	1.79
Other auxiliary installations.....	.25	2.75
	.57	6.30
Total costs.....	9.33	100.00